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NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 91-4

DEVELOPMENT OF A STANDARD TO OBJECTIVELY DEFINE AND MEASURE THE END-TO-END QUALITY OF TELECONFERENCING/ VIDEOPHONE SYSTEMS

FEBRUARY 1991

OFFICE OF THE MANAGER
NATIONAL COMMUNICATIONS SYSTEM

WASHINGTON, D.C. 20305

February 1991 Final

Development of a Standard to Objectively Define and Measure the End-to-End Quality of Teleconferencing/Videophone Systems

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NCS TIB 91-4

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This report covers the activites of personnel in support of American National Standards Institute (ANSI) Committee T1Q1.5 in its effort to establish a performance standard for digital video teleconferencing. This report gives the background of the development of video transmission standards starting from the early days of TV Network broadcasting. It covers the requirements unique to digital video teleconferencing and describes the current status of the standardization effort. It summarizes the details and efforts that are expected to be needed to finalize a tight but practical standard.

Video teleconferencing
ISDN

Digital transmission
TV Transmission

205

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NCS TECHNICAL INFORMATION BULLETIN 91-4

DEVELOPMENT OF A STANDARD TO OBJECTIVELY DEFINE AND MEASURE THE END-TO-END QUALITY OF TELECONFERENCING/VIDEOPHONE SYSTEMS

JANUARY 1991

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identified, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents and overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of teleconferencing. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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DEVELOPMENT OF A STANDARD TO OBJECTIVELY DEFINE AND MEASURE THE END-TO-END QUALITY OF TELECONFERENCING/VIDEOPHONE SYSTEMS

February, 1991

FINAL REPORT
DCA100-87-C-0078

Submitted to:
NATIONAL COMMUNICATIONS SYSTEM
WASHINGTON, DC

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1.0 INTRODUCTION AND SUMMARY

This document summarizes work performed by Delta Information Systems, Inc. (DIS) for the National Communications System (NCS), Office of Technology and Standards. This office is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, whose use is mandatory for all Federal departments and agencies.

This report covers the activities of DIS personnel in support of American National Standards Institute (ANSI) Committee T1Q1.5 in its effort to establish a performance standard for digital video teleconferencing. Clearly the standardization activities of NCS and ANSI have the same objectives, and DIS has been providing liaison between the two organizations.

Section 2.0 gives the background of the development of video transmission standards starting from the early days of TV network broadcasting. Section 3.0 covers the requirements unique to digital video teleconferencing and describes the current status of the standardization effort. Section 4.0 summarizes the above and details the efforts that are expected to be needed to finalize a tight but practical standard.

2.0 BACKGROUND

Efforts to standardize the quality requirements of TV transmission date back to the 1950's. In that period the TV broadcast networks were going through the phases of major development. Early network connections used a mix of common carrier and independently owned facilities of often questionable and inconsistent quality. Therefore, the Electronic Industries Association (EIA) undertook the task of developing Electrical Performance Standards for Television Relay Facilities, nomenclatured RS-250. This was a formidable undertaking. At first, performance parameters had to be defined, and subsequently numerical limits established through extensive subjective picture quality evaluations which were correlated with objective measurements.

The tremendous development of the TV broadcast industry necessitated many additions and refinements. The latest version of the EIA standard is RS-250-B, published in September 1976. During the same time frame the Network Transmission Committee (consisting of ABC, CBS, NBC and PBS) issued NTS Report No. 7 which is very similar, though somewhat simplified, to RS-250-B. EIA continued its task and worked on an updated version RS-250-C but this effort was suspended just short of completion. ANSI subsequently took over and issued Standard T1.502 in 1988. This document still has much similarity to RS-250-B but contains many refinements and additional performance parameters necessitated by the many new developments in TV broadcast equipment and techniques.

The common transmission method for standard analog TV signals has for a long time been frequency modulated microwave. A frequent deterioration associated with this technique is non-linearity of the modulation and demodulation process. Therefore, all analog TV transmission standards emphasize performance parameters which are affected by non-linearity of the transmission system.

Actually T1.502 contains five standards in one because it specifies different performance limits for different reference circuits defined by the composition and length of the transmission service channel. This is necessary because analog picture impairments are additive, though not necessarily linearly.

During the 1980's the advantages of digital transmission became more and more obvious and its application to TV signals was a logical development. However, direct digitization of a standard NTSC color signal would result in a bit rate in the 100 Mbps range which is excessive for normally available transmission channels. A limited amount of data compression is needed to reduce the transmitted data rate to about 45 Mbps to make transmission over a DS-3 channel within the fast developing Integrated Service Digital Network (ISDN) possible. Algorithms for this compression are being tested by ANSI Committee T1Y1.1 (see Document No. T1Y1.1/90-502R3, dated April 13, 1990) for the purpose of subsequent standardization. The Wideband Subworking Group of ANSI Committee T1Q1.5 is well along in developing a performance standard entitled "Digital Transport of System M-NTSC Television Signals - Analog Interface Specifications and Performance Parameters". The latest draft of this document is T1Q1.5/90-205R4, dated October 25, 1990. Its contents are based on the analog standard T1-502 but include several refinements and added parameters necessitated by the digitization and compression process.

3.0 VIDEO TELECONFERENCING/VIDEO TELEPHONY STANDARD

Another Subworking Group of ANSI Committee T1Q1.5 was formed to develop a performance standard entitled "Digital Transport of Video Teleconferencing/Video Telephony Signals - Analog Interface Specifications and Performance Parameters". This subworking group is composed of members of government agencies, exchange carriers, broadcasting networks and industry. Many technical contributions have been submitted by all member organizations. Several draft versions of the standard have been prepared with the most recent revision dated January 22, 1991. It is attached to this report as Appendix A.

ANSI Standard T1.502 and the subsequent broadcast quality draft Standard T1Q1.5/90-205 the preparation of which is well advanced form excellent points of departure for the development of the new standard. However, revie' and discussion of the many technical contributions have made it obvious that there are fundamental differences between high data rate broadcast and low data rate teleconferencing service. Reduction of the transmitted data rate from about 45 Mbps to the range between 64 and 1536 Kbps results in serious constraints on the output picture. On the other hand, most applications of teleconferencing and videophone can tolerate a picture with considerable impairments without jeopardizing its usefulness. Some of the most important new and changed factors are as follows:

- Motion must be introduced as a most important feature.
- Motion artifacts must be defined
- Methods for measurement of digital and motion effects must be developed.
- Some performance parameters must be added while others may be eliminated or at least de-emphasized.
- Conventional performance specifications can and often must be liberalized.
- Different applications call for different levels of performance.

Categorizing of performance parameters can best be accomplished using the very simplified block diagram of a digital video system shown in Figure 3.1. It contains the main system elements that determine transmission quality and indicates the sections which influence spatial and temporal performance.

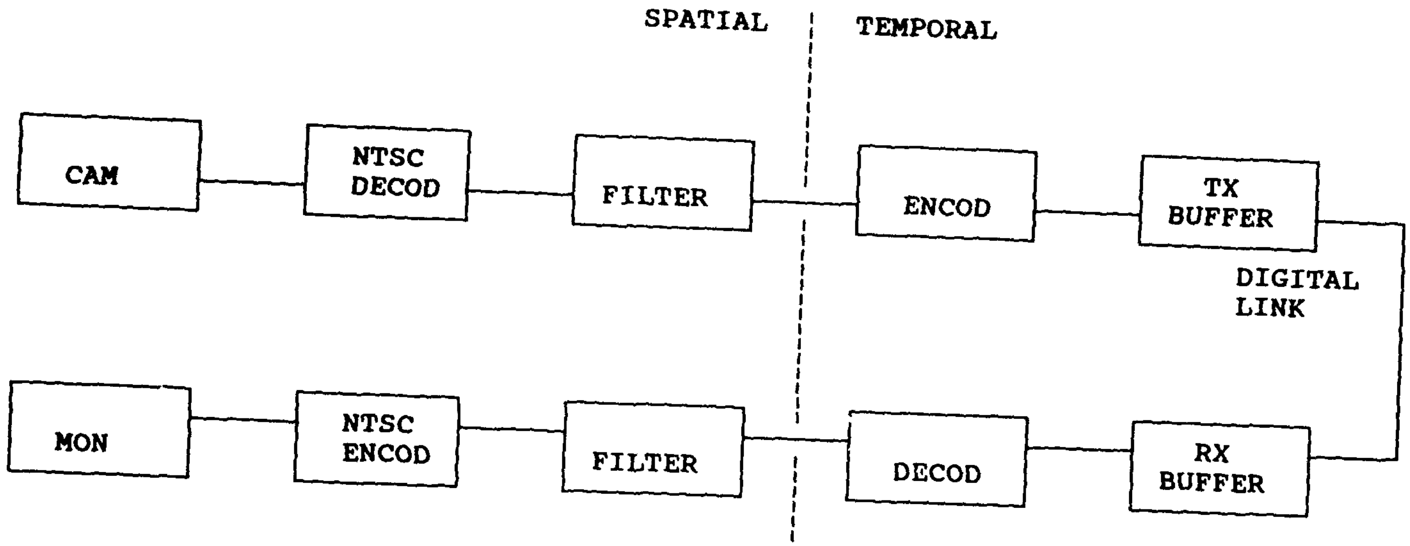

FIGURE 3.1

TYPICAL DIGITAL VIDEO SYSTEM

Conventional still picture parameters used for instance in ANSI T1.502 are spatial which means that they can be evaluated with stationary signals. Most additional parameters are temporal and concerned with motion rendition.

Considerable effort has been spent on the outline and organization of the draft standard. It started out identical with T1.502 but has meanwhile been modified to better match the requirements and limitations of a teleconferencing system. More modifications and simplifications will be necessary. All numerical performance requirements must still be established or at least reviewed and often modified for teleconferencing. For instance, the latest revision of the standard still contains the frequency response specification of T1.502 for a short haul transmission channel which is inherently impossible to satisfy by any teleconferencing codec. Other conventional still picture parameters have specification limits which are much tighter than necessary and sometimes not obtainable. Since the analog circuit elements controlling these parameters are well developed and generally performing flawlessly, they are not critical but reasonable limits should be specified. On the other hand, motion rendition is determined by the algorithm of the encoding/decoding process which therefore becomes the main factor when assessing the performance of a teleconferencing codec.

The technical contributions submitted by the various member organizations of the T1Q1.5 Subworking Group cover the gamut of spatial and temporal performance parameters. The largest portion of contributions deals with the definition of motion artifacts and methods of their recognition and objective numerical measurement. The committee has essentially good agreement on the artifacts that should be considered but no methods of measurement have so far been established. Many ingenious and sophisticated techniques have been developed some of which are excellent in a lab environment but suffer from drawbacks in practical use. Several techniques require the simultaneous availability of input and output signals at the point of test which is not possible with end-to-end testing. They may also require highly trained personnel for their implementation.

Another topic unique to teleconferencing which has been the subject of many discussions and contributions is the specific applications of the service and the required level of performance. Every contributor seems to have a different outlook on that subject and agreement is difficult to achieve. Ultimately it will be necessary to limit consideration to three to six typical applications with associated levels of performance.

Even though the standard to be developed is an American National Standard for use in systems within the USA it cannot ignore events in the world community. The CCITT has long recognized that video teleconferencing has a worldwide scope and compatibility between different countries is essential which is a particular problem due to the differences between NTSC, PAL, and SECAM systems. CCITT H.261 Recommendation calls for a Common Interface Format (CIF) which can be made compatible with any other system. There are two versions with different performance levels (CIF and QCIF). The Teleconferencing Subworking Group is taking these recommendations together with US proprietary algorithms into account when formulating the new standard.

DIS is represented in the Teleconferencing Subworking Group by its President, Mr. Richard Schaphorst. He also is one of the U.S. members of CCITT Study Group XV, and has often provided liaison between the two organizations. He and his associates have prepared numerous technical contributions to both organizations in most areas of deliberation. These contributions can be grouped into the following main topics as contained in Appendices B to J.

B. Videophone Test Tape
C. Subjective Tests
D. Levels of Service
E. Motion Artifacts
F. Objective Motion Performance Parameters and Tests
G. Teleconferencing Picture Formats
H. Still Picture Performance Parameters
J. Outline Revisions

4.0 CONCLUSION AND RECOMMENDATIONS

This report covers the development and status of the effort of the Subworking Group on Video Teleconferencing/Video Telephony of ANSI Committee T1Q1.5. It is backed up by appendices containing the main contributions furnished by DIS personnel. The outline of an end-to-end performance standard has been prepared and tentative numerical requirements for many parameters have been inserted. However, many parameters, mainly those relating to motion performance, are merely listed by name without definition, standard value and method of measurement. In general, the whole draft standard must still be adapted to teleconferencing which includes a thorough review of existing and addition of new material.

It has become obvious that the resulting document will have to consist of a multiplicity of standards, similar to the existing T1.502. However, there will be more fundamental differences between its versions, not merely those due to circuit length and composition which become minor factors in all digital transmission, particularly due to the recent emergence of ISDN. When using equipment according to CCITT Recommendation H.261, the different sampling rates of CIF and QCIF and the resulting filter bandwidths make it mandatory to have two different frequency response standards. Furthermore, as pointed out in several appendices, different applications call for different levels of service which result in different performance requirements and emphasis on specific parameters. Obviously, the number of versions of the standard should be held to a minimum but at this time it cannot be predicted how many will be required.

DIS will continue its past efforts with contributions in all applicable areas. It is expected that these activities will be concentrated on developing techniques for objectively measuring the motion rendition capability of teleconferencing codecs. Both subjective and objective tests will primarily be performed on codecs built according to CCITT Rec. H.261 as they become available. Test results will be checked for correlation between the two methods. Use of subjective test sequences representing typical applications of teleconferencing will make it possible to establish first subjective and subsequently objective limits of acceptability for these applications. The result will be a standard containing significant yet realistic and readily enforceable performance limits.

APPENDIX A

COMMITTEE T1
CONTRIBUTION

Document Number T1Q1.5/91-107
Revision 01, January 22, 1990

STANDARDS PROJECT: Analog Interface Performance Specifications for Digital Video Teleconferencing/ Video Telephony Service.

TITLE: Draft Standard

ISSUE ADDRESSED: Draft Standard

SOURCE: Subworking Group on Video Teleconferencing/Video Telephony.

DATE: February 21, 1991

DISTRIBUTION TO: T1Q1.5 Subworking Group on Video Teleconferencing/Video Telephony.

KEYWORDS: Standard, Video, Teleconferencing, Telephony.

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1

AMERICAN NATIONAL STANDARD
FOR TELECOMMUNICATIONS —
DIGITAL TRANSPORT OF
VIDEO TELECONFERENCING/VIDEO TELEPHONY SIGNALS —
SYSTEM M-NTSC ANALOG INTERFACE SPECIFICATIONS
AND PERFORMANCE PARAMETERS

FOREWORD (This foreword is not part of the American National Standard (numbered).

This standard addresses the performance characteristics of **Video Teleconferencing/Video Telephony** (VTC/VT) service channels employing digital transport. The performance parameters are expressed as a function of **a single coding** between the end points of a transmission service channel. Performance definitions and measurement methods are provided if appropriate. Interface definitions are provided to facilitate compatibility between end users, service providers, and carriers.

Each transmission service channel may be used by itself or may become part of a larger transmission channel.

This standard for transmission performance is intended to provide a means of assuring and maintaining transmission performance quality between defined transmission service channel interfaces.

Video signals originated or transmitted in accordance with standards other than system M-NTSC may not necessarily be compatible with the specifications of this standard.

Suggestions for improvement of this standard are welcome. They should be sent to The Exchange Carriers Standards Association - Committee T1 Secretariat, Suite 200. 5430 Grosvenor Lane, Bethesda, MD 20814-4505.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee T1 - Telecommunications. Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, Committee T1 had the following officers and members:

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National Bureau of Standards
National Communications System
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At the time it approved this standard, the Technical Subcommittee for Performance T1Q1 had the following officers and members:

Godfrey Williams, Chair
R. E. Jensen, Vice-Chair
R. B. Waller, Secretary

Work Group T1Q1.5 Wideband Program, which developed this standard had the following officers and participants:

Howard Meiseles, Chair
Steve Gloeckle, Vice-Chair
Warner Johnston, Secretary

List of members will be added later.

Participants

John Bekerich	David Bennett	Lyle Bradt
Ralph Brainard	Fred Camarillo	Hugh Chen
Gerard Clement	Bill Coufal	Tom Garcia
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Editorial Committee of the Video Teleconferencing/Video Telephony Standard

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Stephen Wolf

CONTENTS

American National Standard for Telecommunications — Digital Transport of Video Teleconferencing/Video Telephony Signals — System M-NTSC Analog Interface Specifications and Performance Parameters

1. Scope, Purpose and Application

1.1 Scope. This standard covers analog interface specifications and performance parameters of Video Teleconferencing/Video Telephony (VTC/VT) transmission service channels employing digital transport. VTC/VT signals created or transmitted in accordance with other standards or make-ups may not necessarily be compatible with the specifications of this standard.

This standard specifies the performance of transmission service channels employing digital transport provided to convey VTC/VT signals and their associated audio signals only. Performance values are for a single coding and are allocated by grades of service (refer to Figure 0). Performance definitions and measurement methods are provided if appropriate. Interface specifications are provided to facilitate compatibility between end users, service providers, and carriers.

The performance characteristics identified within this standard apply to the transmission quality between the defined interfaces. Those interfaces are between VTC/VT transmission service providers and end users. This standard defines neither the interconnection nor the performance characteristics of specific apparatus or equipment.

1.2 Purpose. The purpose of this standard is to assure the uniform application of standard values of transmission parameters for VTC/VT signals transported digitally by portions of the telecommunications network. It is intended to provide a common understanding by **manufacturers, carriers**, and their customers.

1.3 Application. The primary applications of this standard are for specifying and evaluating the performance of a VTC/VT transmission service employing digital transport provided by common carriers. This service is used to transport the audio and video portions of the VTC/VT signals.

2. References and Related Standards

2.1 American National Standards. This standard is intended to be used in conjunction with the following American National Standards.

2.2 Other Related National Standards

2.3 Other Related Standards

2.4 Other Related Publications

3. Definitions

blocking: The received video imagery posses rectangular or checkerboard patterns not present in the original.

blurring/smearing: The received video imagery has lost edges and detail present in the original.

common mode rejection-audio: Common mode rejection is the degree to which unwanted signals coupled into both sides of a balanced line are rejected by the input of the transmission service channel.

NOTE: Standard Value:

A. The common mode rejection ratio shall be greater than x dB. 20 Hz - 7.0 kHz and at least x dB at 60 Hz.

B. The input common mode voltage range shall be at least 24 peak volts within the service bandwidth of the transmission channel. Within this range, differential mode signals shall be passed within the total distortion specification in 5.2.3 when the common mode signal is counted as a distortion product. Throughout this voltage range the common mode signal shall be rejected as per x.

C. The system shall be capable of withstanding at least 50 volts peak, within the service bandwidth, of common mode, or differential mode, continuously without damage.

D. Output common mode noise, shall be at least x dB below the nominal audio level (measured to ground).

edge busyness: The deterioration of motion video such that the outlines of moving objects are displayed with randomly varying activity.

frame cuts: Video imagery where adjacent frames are highly uncorrelated.

image persistence: The appearance of earlier faded video frames of a moving and/or changing object within the current frame. (e.g., an object that was erased continues to appear in the received video imagery.)

jerkiness: The original smooth and continuous motion is perceived as a series of distinct 'snapshots'.

longitudinal balance — audio. Longitudinal Balance is defined as the ratio of the disturbing longitudinal source voltage, V_s, and the resultant metallic voltage, V_m, at the same frequency of the network under test, expressed in dB. The degree of balance between each conductor of a wire pair or equipment unit and ground is a measure of immunity to noise induced from external sources.

NOTE:

A. The longitudinal-to-metallic balance coefficient is expressed as:

$$\text{Longitudinal Balance (dB)} = 20 \log_{10} |V_s / V_m|$$

B.

Frequency	Range	Standard
20 to	250 Hz	$\geq$ x dB
251 to	7000 Hz	$\geq$ x dB

mosquito noise: The quantizing noise generated by the block processing of moving objects that gives the appearance of false small moving objects (e.g., a mosquito flying around a person's head and shoulders).

motion response degradation: The deterioration of motion video such that the received video imagery has suffered a loss of spatio-temporal resolution.

motion video: Video imagery which conveys movement.

spatial application: For spatial applications, emphasis is placed on attaining high spatial resolution, possibly at the expense of reduced temporal positioning accuracy (or increased jerkiness). This application group is concerned with the ability to read small characters and see fine detail in still video and/or motion video which contains a very limited amount of motion.

spatial resolution: A measure of the ability of a video transmission system to accurately reproduce still scenes.

still video: Video imagery which does not convey movement.

temporal application: For temporal applications, emphasis is placed on temporal positioning accuracy (or reduced jerkiness), possibly at the expense of reduced spatial resolution. This application group is concerned with the ability to accurately distinguish such items as facial expressions and lip movements in face to face and/or conference room settings.

temporal response: A measure of the ability of a video transmission system to accurately reproduce moving scenes.

video: (1) The visually displayed images of video teleconferencing/video telephony. (2) Of or pertaining to the visually displayed images of video teleconferencing/video telephony.

video frame: A single frame of video.

video imagery: A contiguous sequence of video frames.

video teleconferencing/video telephony motion artifacts: In a video teleconferencing/video telephony system, subjectively observable deteriorations of motion video due to image data compression.

3.1 Special Word/Phrase Usage.

average picture level (APL). The average level of the picture signal during active scanning time integrated over a frame period and defined as a percentage of the range between blanking and reference white.

coding. The digital encoding and decoding of an analog signal with only digital transmission facilities between the encoding and decoding equipment.

digital transport. A portion of the telecommunication network using digital methods for the transmission of signals from one point to another to complete a transmission service channel. A transmission service channel may have one or more digital transport portion(s).

transmission service channel. A transmission service channel is a transmission path between designated points.

video teleconferencing/video telephony service (VTC/VT). The transmission of video signals capable of portraying motion and the accompanying audio signals between two or more locations using digital transmission facilities. A typical example of this service is video teleconferencing between groups of personnel located at two or more locations.

3.2 Video Signals.

3.2.1 Video Signal Description. The waveform terminology used throughout the standard is in accordance with Figure 1, where the standard video-signal waveform terminology is shown and measured in IRE units as shown in Figure 2.

3.2.2 Test Signal Description. Reference to time (T) in the description of the following test signals refers to the half-amplitude pulse-width duration and not the rise time nor the fall time of a pulse transition and has a value of 125 nanoseconds.

3.2.3 Static Test Signals.

3.2.3.1 Composite Test Signal. The composite test signal shown in Figure 3, consists of a line bar (125 nanosecond rise time and fall time), a 2T pulse (250 nanosecond half-amplitude duration), a 12.5T (1.5625 microseconds half-amplitude duration) chrominance pulse, and a modulated 5-riser staircase signal superimposed upon standard synchronizing and blanking signals. Reference A and B are the measurement points utilized in the measurement of insertion gain and insertion-gain variation.

3.2.3.2 Combination Test Signal. The combination test signal shown in Figure 4, consists of a white flag, a multiburst, and a 3-level chrominance signal superimposed upon standard synchronizing and blanking signals.

4. Baseband VTC/VT Interface Specifications

4.1 Video Signal Electrical Interface Specifications.

4.1.1 Impedance.

4.1.1.1 Source Impedance.

4.1.1.1.1 Definition. The video source impedance Z_S *shown in Figure* 15, is the impedance presented to the input terminals of a transmission service channel or other video baseband input point by the output terminals of the signal source. Proper source impedance is required for service channel evaluation.

4.1.1.1.2 Standard Value. The standard value shall be 75 ohms, unbalanced to ground, with a return loss of at least XX dB over the frequency range of the respective service bandpass.

4.1.1.1.3 Method of Measurement. The source impedance shall be measured by using impedance measurement equipment and the return loss calculated from the following formula:

$$\text{Return loss (dB)} = 20 \log_{10} \left| \frac{Z + Z_M}{Z - Z_M} \right|$$

Where

Z = specified standard impedance
Z_M = measured impedance

Alternately, the return loss may be measured using a return loss bridge.

4.1.1.2 Input Impedance.

4.1.1.2.1 Definition. The video input impedance of a transmission service channel, Z_I shown in Figure 15, is the impedance presented by the input terminals of a transmission service channel or other video baseband input point.

4.1.1.2.2 Standard Value. The standard value shall be 75 ohms, unbalanced to ground, with a return loss of at least XX dB over the frequency range of the respective service bandpass.

4.1.1.2.3 Method of Measurement. See Section 4.1.1.1.3.

4.1.1.3 Output Impedance.

4.1.1.3.1 Definition. The video output impedance of a transmission service channel, Z_O shown in Figure 15, is the impedance presented by the output terminals of a transmission service channel or other baseband output point.

4.1.1.3.2 Standard Value. The standard value shall be 75 ohms, unbalanced to ground, with a return loss of at least XX dB over the frequency range of the respective service bandpass.

4.1.1.3.3 Method of Measurement. See Section 4.1.1.1.3.

4.1.1.4 Load Impedance.

4.1.1.4.1 Definition. The video load impedance of a transmission service channel, Z_L shown in Figure 15, is the impedance presented by the input terminals of the device which will terminate the video baseband output of the transmission service channel. Proper load impedance is required for service channel evaluation.

4.1.1.4.2 Standard Value. The standard value shall be 75 ohms. unbalanced to ground, with a return loss of at least XX dB over the frequency range of the respective service bandpass.

4.1.1.4.3 Method of Measurement. See Section 4.1.1.1.3.

4.2 Video Signal.

4.2.1 Polarity of the Picture Signal.

4.2.1.1 Definition. The polarity of the picture signal of a transmission service channel is the sense of the potential of a portion of the signal representing a dark area of a scene relative to the potential of a portion of the signal representing a light area. Polarity is stated as "black positive" or "black negative". It is the polarity presented to the transmission service channel input terminals and presented by the transmission service channel output terminals.

4.2.1.2 Standard Value. The polarity of the picture signal shall be "Black Negative".

4.2.1.3 Method of Measurement. The polarity of the picture signal shall be determined by use of an oscilloscope or waveform monitor of known deflection polarity.

4.2.2 Input Signal.

4.2.2.1 Signal Level.

4.2.2.1.1 Definition. The input signal level of a transmission service channel is the difference in voltage between sync tip (-40 IRE units) and reference white (100 IRE units) of a composite picture signal presented to the video baseband input terminals. It is expressed in volts.

4.2.2.1.2 Standard Value. The standard value shall be a nominal 1 volt peak-to-peak difference between sync tip and reference white, 140 IRE units (see Figures 1 and 2).

4.2.2.1.3 Method of Measurement. The input signal level shall be measured by means of a properly calibrated and terminated oscilloscope or waveform monitor.

4.2.2.2 Time Base Error.

4.2.2.2.1 Definition. Time base error is defined as the difference between the instantaneous time base (which is the time between the 50% value of the leading edges of two successive horizontal sync pulses) and the time base averaged over one frame. The time base defined in this parameter is typically that which is generated by a video tape machine.

4.2.2.2.2 Standard Value.

4.2.2.2.3 Method of Measurement. The input time base error is measured by applying the input signal to a time base error reading instrument.

4.2.2.3 Unweighted Signal to Noise Ratio.

4.2.2.3.1 Definition. The signal-to-noise ratio of the input signal is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally 0.714 volt = 100 IRE units), to the peak-to-peak noise level. The noise may be mixed thermal and quantizing noise and is a function of the equipment between the picture source and the transmission service channel input. Synchronizing signals are not included in the signal measurement. It is measured at the output of the distribution equipment providing the signal and is the responsibility of the channel user to meet the standard value.

NOTE:

A. The definition does not call for weighting the noise portion of the signal but does require that the noise be band limited to the pass band of the transmission service channel input equipment.

B. The input of the transmission service channel must tolerate noise that is out of band and could have voltage spikes several times that of the band limited noise.

4.2.2.3.2 Standard Value. The standard value shall be greater than XX dB.

4.2.2.3.3 Method of Measurement.

4.2.2.4 Non-Useful DC Component.

4.2.2.4.1 Definition. The non-useful DC component of the input picture signal is any DC component which is unrelated to the signal. It will be present only as a result of distribution equipment after the picture source.

4.2.2.4.2 Standard Value. $\leq$0.XX volt across a standard termination (75 ohms).

4.2.2.4.3 Method of Measurement. The non-useful DC component of the picture signal shall be measured by means of a suitable DC instrument with the picture source removed from the distribution equipment and the equipment terminated.

4.2.2.5 Non-Useful AC Component.

4.2.2.5.1 Definition. The non-useful AC component of the input picture signal is composed of additive signals below 600 Hz affecting both luminance and synchronizing signals. It will be present only as a result of distribution equipment after the picture source.

4.2.2.5.2 Standard Value.

4.2.2.5.3 Method of Measurement.

4.2.3 Output Signal.

4.2.3.1 Signal Level.

4.2.3.1.1 Definition. The output signal level of a transmission service channel is the difference in voltage between sync tip and reference white of a composite picture signal presented by the video baseband output terminals. It is expressed in volts peak-to-peak.

4.2.3.1.2 Standard Value. The output signal shall be a faithful reproduction of the input signal, subject to the parametric variations permitted by the performance characteristics set forth in this standard.

4.2.3.1.3 Method of Measurement. The output signal level shall be measured by means of a properly calibrated and terminated oscilloscope or waveform monitor.

4.2.3.2 Time Base Error.

4.2.3.2.1 Definition. Time base error is defined as the difference between then instantaneous time base (which is the time between the 50% value of the leading edges of two successive horizontal sync pulses) and the time base averaged over one frame.

4.2.3.2.2 Standard Value.

4.2.3.2.3 Method of Measurement. Apply a calibrated video signal to the input of the transmission service channel. Measure the output time base error by applying the output signal of the transmission service channel to a time base error reading instrument. The output Time Base Error shall not vary more than the standard value from the input.

4.2.3.3 Non-Useful DC Component.

4.2.3.3.1 Definition. The non-useful DC component of the output picture signal is any DC component which is unrelated to the signal. It will be present only as a result of the transmission equipment.

4.2.3.3.2 Standard Value. $\leq$x volt across a standard load (75 ohms).

4.2.3.3.3 Method of Measurement. The non-useful DC component of the picture signal shall be measured by means of a suitable DC instrument with the video signal removed and the transmission service channel input terminals terminated.

4.2.4 Input to Output Signal Timing Error.

4.2.4.1 Definition. The input to output signal timing error is the variation in subcarrier phase at the output of the transmission service channel relative to that at the input of the transmission service channel.

4.2.4.2 Standard Value.

4.2.4.3 Method of Measurement.

4.3 Audio Signal Electrical Interface Specifications.

4.3.1 Impedance.

4.3.1.1 Source Impedance.

4.3.1.1.1 Definition. The audio source impedance of a transmission service channel, Z_S, shown in Figure 16, is the impedance presented to the input terminals by the output terminals of the signal source. Proper source impedance is required for transmission service channel evaluation.

4.3.1.1.2 Standard Value. The standard value shall be 600 ohms, nominally resistive, longitudinally balanced, and with a return loss of at least x dB over the frequency range of the respective service bandpass.

4.3.1.1.3 Method of Measurement. The source impedance shall be measured by using impedance measurement equipment and the return loss calculated from the following formula:

$$\text{Return loss (dB)} = 20 \log_{10} \left| \frac{Z + Z_M}{Z - Z_M} \right|$$

Where

Z = specified standard impedance
Z_M = measured impedance

Alternately, the return loss may be measured using a return loss bridge.

4.3.1.2 Input Impedance.

4.3.1.2.1 Definition. The input impedance of a transmission service channel Z_i shown in Figure 16, is the impedance presented by the input terminals of a transmission service channel.

4.3.1.2.2 Standard Value. The standard value shall be 600 ohms, nominally resistive, longitudinally balanced, specified common mode rejection ratio and with a return loss of at least x dB over the frequency range of the respective service bandpass.

4.3.1.2.3 Method of Measurement. See 4.3.1.1.3.

4.3.1.3 Output Impedance.

4.3.1.3.1 Definition. The output impedance of a transmission service channel, Z_o shown in figure 16, is the impedance presented by the output terminals of a transmission service channel.

4.3.1.3.2 Standard Value. The standard value shall be 600 ohms, nominally resistive, longitudinally balanced, and with a return loss of at least x dB over the frequency range of the respective service bandpass.

4.3.1.3.3 Method of Measurement. See 4.3.1.1.3.

4.3.1.4 Load Impedance.

4.3.1.4.1 Definition. The load impedance of a transmission service channel, Z_l shown in Figure 15, is the impedance presented by the input terminals of the device which will terminate the audio output of the transmission service channel. Proper load impedance is required for channel evaluation.

4.3.1.4.2 Standard Value. The standard value shall be 600 ohms, nominally resistive, longitudinally balanced, and with a return loss of at least x dB over the frequency range of the respective service bandpass.

4.3.1.4.3 Method of Measurement. See 4.3.1.1.3.

4.3.2 Audio Signal.

4.3.2.1 Test Equipment. Test equipment shall be calibrated in accordance with the manufacturers recommendations and terminated as specified.

4.3.2.2 Input Signal Level.

4.3.2.2.1 Definition. The input signal level to a transmission service channel is the signal level across the transmission service channel input impedance. When the signal is sinusoidal the input signal level is expressed in dBm.

4.3.2.2.2 Standard Value. The peak operating level of the input signal to the transmission service channel across the standard impedance is equal to the peaks of a sine-wave whose average power is 0 dBm. The nominal level is -16 dBm, and the minimum clip level is +9 dBm.

NOTE:

A. Clip level is defined as the level at which the total distortion exceeds 1%.

B. This 9 dBm level is only to be applied at the end users interface for program audio services as described in this document. This level is only used for an out-of-service test.

4.3.2.2.3 Method of Measurement. The audio input signal level shall be measured by audio test equipment terminated as specified. Sinusoidal waveforms may be measured using a properly calibrated voltage or power meter.

4.3.2.3 Output Signal Level.

4.3.2.3.1 Definition. The output signal level of a transmission service channel is the signal level across the transmission service channel output impedance.

4.3.2.3.2 Standard Value. The output signal shall be a faithful reproduction of the input signal, subject to the parametric variations permitted by the performance characteristics set forth in this standard.

4.3.2.3.3 Method of Measurement. The audio output signal shall be measured by audio test equipment terminated as specified. Sinusoidal waveforms may be measured using a properly calibrated voltage or power meter and expressed in dBm.

4.3.2.4 Signal Polarity.

4.3.2.4.1 Definition. The polarity of the signal is the polarity sense of a nonsymmetrical audio transient signal on the A (tip) terminal with respect to the B (ring) terminal of the balanced pair (see Figure 16).

4.3.2.4.2 Standard Value. The polarity of the audio signal at the output of the transmission service channel shall be the same as that at the input of the transmission service channel.

4.3.2.4.3 Method of Measurement. A nominal 400-Hz clipped sine wave (1/2 wave rectified, see Figure 17) shall be fed into the input of the transmission service channel. An oscilloscope of a known deflection shall be used at both ends of the transmission service channel to determine the polarity sense of the audio signal.

4.3.2.5 Non-Useful DC Component.

4.3.2.5.1 Definition. The non-useful dc component of the audio channel is any dc component which is unrelated to the signal and is also present when the audio signal is removed.

4.3.2.5.2 Loop Requirements. When the audio signal is removed, direct current flow shall be equal to or less than X through a zero ohm termination across the audio channel input or output terminals.

4.3.2.5.3 Longitudinal Requirements. Direct current flow shall be equal to or less than X when the terminals are shorted together and measured through a zero impedance to ground.

5. Baseband VTC/VT Performance Specifications

5.1 Video Signal Performance Characteristics.

5.1.1 Video Signal Linear Distortions.

5.1.1.1 Amplitude Response Versus Frequency Characteristic.

5.1.1.1.1 Definition. The video amplitude response versus frequency characteristic of a transmission service channel is an expression of amplitude variation as a function of the baseband frequency of a sine-wave voltage when applied to the transmitting terminal baseband input and measured at the receiving terminal baseband output.

5.1.1.1.2 Standard Value. The selected frequency values at 50 IRE units listed below are representative of a half-level multiburst signal.

One Coding

Amplitude response versus frequency characteristics is shown in Figure 18.

50 IRE unit sine wave

MHz	IRE units (to be determined)
0.5	+ to -
1.0	+ to -
2.0	+ to -
3.0	+ to -
3.58	+ to -
4.2	+ to -

5.1.1.1.3 Method of Measurement. An out-of-service measurement may be performed by using a test signal consisting of a swept-frequency signal with synchronizing and blanking signals applied to the transmission service channel input terminals. The sweep rate shall be equal to the picture field rate and phased to coincide with the period of one field. The suggested sweep width shall be 5 MHz and the amplitude of the video sweep voltage shall extend from 15% to 65% of the luminance signal level (50 IRE units). Harmonic content of the sweep voltage should be the minimum possible, preferably less than 1%. The measurement arrangement shall permit viewing of the input and output sweep voltages on calibrated oscilloscopes having adequate bandwidth.

Alternately, in-service or out-of-service measurement may be performed by using a 50-IRE unit multiburst portion of the combination test signal (Figure 4) or a 50-IRE-unit multipulse test signal (Figure 5). The amplitude response versus frequency may be measured by comparing the amplitude of the bursts of either the multiburst to the white flag.

NOTE: The multipulse waveform does not supply a 0.5 MHz test zone.

5.1.1.2 Chrominance-to-Luminance Gain Inequality

5.1.1.2.1 Definition. Chrominance-to-luminance gain inequality of a transmission service channel is the difference in gain of the chrominance signal (approximately 3-4 MHz) and the low-frequency luminance signal (less than 600 kHz). It is measured as relative chrominance level (RCL) at the transmission service channel output terminals.

5.1.1.2.2 Standard Value. The standard value for one coding is ±x IRE units.

5.1.1.2.3 Method of Measurement. The 12.5T modulated pulse portion of the composite test signal, shown in Figure 3, is used for this measurement. The test signal shall be applied to the transmission service channel's input terminals.

A symmetrical bowing of the 12.5T pulse base indicates a chrominance-to-luminance gain inequality. If the bowing is in the upward direction, the chroma inequality is negative. If the bowing is in the downward direction, the chroma inequality is positive. The maximum shift of the base of the 12.5T pulse from the display baseline is a measure of the amount of chroma gain inequality. This is exactly equal to the displacement of the peak of the pulse from the top of the bar when the distortion is purely linear. Adjust the amplitude of the midpoint (point A) of the line-bar portion of the composite test signal to 100 IRE units with respect to the zero base line (point B). The amplitude of the 12.5T modulated pulse is compared with the midpoint of the previously adjusted bar (point A). The chrominance-to-luminance gain inequality value is twice the measured value of the difference in amplitude between the bar and the 12.5 modulated pulse.

5.1.1.3 Chrominance-to-Luminance Delay Inequality (CLDI).

5.1.1.3.1 Definition. Chrominance-to-luminance delay inequality (CLDI) of a transmission service channel is the difference in transmission time between the chrominance signal (approximately 3-4 MHz) and the low-frequency luminance signal (less than 600 kHz). It is measured at the transmission service channel's output terminals as relative chrominance time (RCT).

5.1.1.3.2 Standard Value. The standard value for one coding is ±x nanoseconds.

5.1.1.3.3 Method of Measurement. The 12.5T pulse portion of the composite test signal shown in Figure 3, is used for this measurement. The test signal shall be applied to the transmission service channel. The test signal shall be viewed on a suitable waveform monitor at the transmission service channel output terminals. After normalizing the 12.5T pulse amplitude to 100 IRE units, chrominance-to-luminance delay inequality can be determined. Identify the amplitude of Y_1 and Y_2 distortion values in the 12.5T pulse base as shown in Figure 19. apply the Y_1 and Y_2 amplitude values to the nomogram of Figure 19. The chrominance-to-luminance delay inequality value is identified at the intersection of the CLDI scale with a straight line placed between the Y_1 and Y_2 values of the nomogram.

5.1.1.4 Short-Time Waveform Distortion (SD).

5.1.1.4.1 Definition. Short-time waveform distortion (SD) of a transmission service channel is the linear waveform distortion of time components from 0.125 microseconds to 1.0 microsecond, that is, time components of the short-time domain. It is measured at the transmission service channel output terminals.

5.1.1.4.2 Standard Value. The standard value for one coding is ≤x percent.

Table 1. Short-Time Waveform Distortion Graticule Limits

Peak Lobes and/or Overshoots*

Time	Positive % Amplitude		Negative % Amplitude	
usec	SD=2%	SD=3.5%	SD=2%	SD=3.5%
0.125	8.0	14.0	4.0	7.0
0.200	5.9	10.3	4.0	7.0
0.300	4.5	7.8	4.0	7.0
0.352	4.0	7.0	4.0	7.0
0.400	3.7	6.5	3.7	6.5
0.500	3.2	5.6	3.2	5.6
0.600	2.8	4.9	2.8	4.9
0.700	2.5	4.4	2.5	4.4
0.800	2.3	4.1	2.3	4.1
0.900	2.1	3.8	2.1	3.8
1.000	2.0	3.5	2.0	3.5

5.1.1.4.3 Method of Measurement. The line-bar portion of the composite test signal shown in Figure 3 is used when measuring short-time waveform distortion. The amplitude of the test signal shall be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The bar portion of the test signal shall be viewed on a waveform monitor with the sweep rate of 2 microseconds using the ANSI/IEEE Standard 511 - 1979 graticule overlay, as shown in Figure 20 with limits specified in Table 1, at the transmission service channel output terminals. Short-time waveform distortion can be read directly from the graticule.

5.1.1.5 Baseline Distortion (BD).

* Peak-to-Peak Values will be twice the listed values.

5.1.1.5.1 Definition. Baseline waveform distortion (BD) of a transmission service channel is the linear waveform distortion of the time components from 1 microseconds to 8 microseconds, that is, time components between the short-time and line-time domains.

5.1.1.5.2 Standard Value.

5.1.1.5.3 Method of Measurement.

5.1.1.6 Line-Time Waveform Distortion (LD).

5.1.1.6.1 Definition. Line-time waveform distortion (LD) of a transmission service channel is the linear waveform distortion of time components from 8 microsecond to 64 microseconds, that is, time components of the line-time domain. It is measured at the transmissions service channel output terminals.

5.1.1.6.2 Standard Value. The standard value for one coding is $\leq$x IRE units P-P.

5.1.1.6.3 Method of Measurement. The line-bar portion of the composite test signal shown in Figure 3 shall be used when measuring line-time waveform distortion (if line-time waveform distortion is measured on an out-of-service basis, then a full-field, 18-microsecond, line bar shall be utilized). The amplitude of the test signal must be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The magnitude of the distortion shall be obtained by measuring, in IRE units. the test signal's bar top peak-to-peak change in amplitude with the amplitude of the bar center adjusted to 100 IRE units at the transmission service channel output terminals. The first and last one microseconds are ignored in this measurement.

5.1.1.7 Superstreaking (SK).

5.1.1.7.1 Definition. Superstreaking waveform distortion of a transmission service channel is the linear waveform distortion of the time components from 64 microseconds to 500 microseconds, that is, time components between the field-time and line-time domains.

5.1.1.7.2 Standard Value.

5.1.1.7.3 Method of Measurement.

5.1.1.8 Field-Time Waveform Distortion (FD)

5.1.1.8.1 Definition. Field-time waveform distortion (FD) of a transmission service channel is the linear waveform distortion of the time components from 500 microseconds to 16 milliseconds, that is, time components of the field-time domain. This is also known as field tilt. It is measured at the transmission service channel output terminals.

5.1.1.8.2 Standard Value. The standard value is x IRE Units.

5.1.1.8.3 Method of Measurement. Field-time waveform distortion measurement is an out-of-service test. The field-bar test signal shown in Figure 6 is used when measuring field-time waveform distortion. Amplitude of the test signal must be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The magnitude of the distortion shall be obtained by measuring, in IRE units, the test signal's peak-to-peak change in amplitude of the bar top with the amplitude of the bar center adjusted to 100 IRE units at the transmission service channel output terminals. In order to avoid leading and trailing overshoots, the first and last 250 microseconds (approximately four television lines) are ignored in this measurement.

5.1.1.9 Long-Time Waveform Distortion (Bounce).

5.1.1.9.1 Definition. Long-time waveform distortion of a transmission service channel is the damped low-frequency transient resulting from a change in APL that affects the dc component of the signal. It is the linear waveform distortion of time components from 16 milliseconds to tens of seconds, that is, time components of the long-time domain. The distortion is characterized by the peak overshoot and settling time. It is measured at the transmission service channel output terminals.

5.1.1.9.2 Standard Value. The standard value is x IRE units peak with a 3-second settling time.

5.1.1.9.3 Method of Measurement. Long-time waveform distortion measurement is an out-of-service test. A flat-field test signal with variable APL shown in Figure 7 shall be applied to the service channel input terminals. The signal shall be switched between 10% and 90% APL at intervals not shorter than five times the settling time. The APL transitions shall be made in less than 10 microseconds. The test signal shall be observed on a slow-sweep waveform monitor and the variation at blanking level noted at the transmission service channel output terminals. A photograph of the oscilloscope display may aid in determining overshoots and settling time. Figure 21 is an example of long-time waveform distortion.

5.1.1.10 Insertion Gain and Insertion-Gain Variation.

5.1.1.10.1 Definition. Insertion gain of a transmission service channel is defined as the difference of a signal's output level compared to its input level. Insertion-gain variation is the change of insertion gain over a specified time interval. It is measured at the transmission service channel output terminals.

5.1.1.10.2 Standard Value. Insertion gain shall be established and periodically maintained at 0 IRE units with a tolerance of x to x IRE units. Insertion-gain variation shall be maintained within the ranges listed below.

	IRE units
Single Encoding Hourly	+x to -x
Over one second	+x to -x

5.1.1.10.3 Method of Measurement. The line-bar portion of the composite test signal shown in Figure 3 is used when measuring insertion gain. The amplitude of the test signal must be verified to be 100 IRE units at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The peak-to-peak amplitude of the midpoint of the flat portion of the line-bar test signal shall be measured at the transmission service channel output terminals. The difference between the measured amplitude of the test signal (level reference points "A" and "B", Figure 3) and its normal amplitude of 100 IRE units is the insertion gain of the transmission service channel.

Insertion-gain variation is measured as the difference in insertion gain at any instant during a specified time interval from the insertion gain at the beginning of that specified time interval.

5.1.2 Video Signal Nonlinear Distortions.

5.1.2.1 Luminance Nonlinearity.

5.1.2.1.1 Definition. Luminance nonlinearity of a transmission service channel is the deviation of the luminance signal from proportionality between the amplitude of the small unit step function, as the level of the step is shifted from blanking level to white level. It is measured at the transmission service channel output terminals.

5.1.2.1.2 Standard Value. The standard value for one coding is $\leq$x IRE units.

5.1.2.1.3 Method of Measurement. The modulated 5-riser staircase portion of the composite test signal shown in Figure 3 shall be used when measuring luminance nonlinearity. The amplitude of the test signal at each step level must be checked for uniformity at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be passed through a differentiating and shaping network of the type shown in Figure 22A with the output of the network connected to the waveform monitor. The network transforms the signal into a train of five pulses of equal amplitude, under zero distortion conditions. Figure 22B shows an example of luminance nonlinearity distortion. The gain of the waveform monitor should be increased to the point where the largest pulse amplitude is 100 IRE units and then the amplitude of the smallest pulse can be measured and recorded. This is the luminance nonlinearity at 50% APL. The above measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL.

5.1.2.2 Differential Gain.

5.1.2.2.1 Definition. Differential gain of a transmission service channel is the change in amplitude of the subcarrier (chrominance) signal as the luminance signal is varied from blanking to white level. It is expressed as a percentage of the maximum level or in IRE units. It is measured at the transmission service channel output terminals.

5.1.2.2.2 Standard Value.

	IRE units	Percent (%)
One Coding	$\leq$x	$\leq$x

5.1.2.2.3 Method of Measurement. The modulated line ramp shown in Figure 9 shall be used when measuring differential gain. The test signal's amplitude over the amplitude range of the line ramp must be checked for uniformity at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be fed through a high-pass filter network and the output of the network connected to the waveform monitor being used for the measurement. The chrominance filter network incorporated into most television waveform monitors is suitable for this test. The gain of the waveform monitor is then adjusted until the highest subcarrier peak-to-peak amplitude is exactly 100 IRE units. The peak-to-peak amplitude of the lowest subcarrier is then measured. The difference between the highest subcarrier amplitude and the lowest subcarrier amplitude is the differential gain distortion at 50% APL. The above measurement procedure should be repeated using the same test signal transmitted at 10% APL and then tested at 90% APL.

A vectorscope may also be used to measure differential gain.

5.1.2.3 Differential Phase.

5.1.2.3.1 Definition. Differential phase of a transmission service channel is the change in phase of the subcarrier (chrominance) signal after it has passed through a transmission service channel as the luminance is varied from blanking level to white level. It is measured at the transmission service channel output terminals.

5.1.2.3.2 Standard Value. The standard value for one coding is $\leq$x degree.

5.1.2.3.3 Method of Measurement. The modulated line ramp shown in Figure 9 shall be used when measuring differential phase. The amplitude and phase of the subcarrier must be checked over the amplitude range of the line ramp for uniformity at the sending end prior to the commencement of the test. Similarly, the phase comparator (vectorscope) at the receiving end should be properly calibrated. A vectorscope display of differential phase with zero distortion is shown in Figure 23A. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be fed to the vectorscope. The differential phase distortion is the measured peak-to-peak change in subcarrier phase at 50% APL. The above measurement procedure should be repeated using the same test signal transmitted at 10% APL and then tested at 90% APL. An example of differential phase distortion is shown in Figure 23B.

5.1.2.4 Chrominance-to-Luminance Intermodulation.

5.1.2.4.1 Definition. Chrominance-to-luminance intermodulation of a transmission service channel is the variation in amplitude of the luminance signal at the transmission service channel output terminals resulting from the superimposition on the input signal of a chrominance signal of specified amplitude.

5.1.2.4.2 Standard Value. The standard value for one coding is $\leq$x IRE unit.

5.1.2.4.3 Method of Measurement. The 3-level chrominance portion of the combination test signal shown in Figure 4 shall be used when measuring chrominance-to-luminance distortion. The amplitude of the test signal at each chrominance level must be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output shall be connected to the waveform monitor, whose response setting is in the LOW PASS mode. The unmodulated portion of the pedestal is adjusted to 50 IRE units. Chrominance-to-luminance intermodulation is the maximum departure in IRE units of the filtered luminance portion of the pedestal relative to a portion of the luminance pedestal which did not contain the chrominance modulation. An example of chrominance-to-luminance intermodulation is shown in Figure 24A and 24B. The above measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL. This standard applies for all values of APL from 10% to 90%.

5.1.2.5 Chrominance Nonlinear Gain.

5.1.2.5.1 Definition. The chrominance nonlinear gain distortion of a transmission service channel is the departure from proportionality in amplitude of the chrominance subcarrier burst packets at the transmission service channel output terminals as the amplitude of the subcarrier is varied from a specified minimum to a specified maximum value at a given luminance level and APL at the transmission service channel input terminals.

5.1.2.5.2 Standard Value.

	Chrominance Signal IRE units	IRE units
One Coding	20 80	± x

5.1.2.5.3 **Method of Measurement.** The 3-level chrominance portion of the combination test signal shown in Figure 4, shall be used when measuring chrominance nonlinear gain distortion. The amplitude of the test signal at each chrominance level must be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals. The test signal at the transmission service channel output terminals shall be connected to the waveform monitor, whose response setting is in the 3.58-MHz band-pass mode. The gain of the waveform monitor is adjusted to the point where the middle subcarrier amplitude is exactly 40 IRE units and then the amplitude of the largest and smallest subcarrier levels are measured. The above measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL.

NOTE: Chrominance nonlinear gain is an out-of-service measurement when APL is utilized in th. performance of this measurement.

5.1.2.6 Chrominance Nonlinear Phase.

5.1.2.6.1 **Definition.** The chrominance phase distortion of a transmission service channel is the variation of the phase of the chrominance subcarrier at the transmission service channel output terminals as the amplitude of the subcarrier is varied from a specified minimum to a specified maximum value at a given luminance level and APL at the transmission service channel input terminals.

5.1.2.6.2 **Standard Value.** The standard value for one coding is $\leq$x degree.

5.1.2.6.3 **Method of Measurement.** The 3-level chrominance portion of the combination test signal shown in Figure 4 shall be used when measuring chrominance nonlinear phase distortion. The amplitude and phase of the test signal at each chrominance level must be checked at the sending end prior to the commencement of the test. The vectorscope at the receiving end should be properly calibrated and terminated. The test signal shall be applied to the transmission service channel input terminals.

The test signal at the transmission service channel output terminals shall be connected to the vectorscope. Under zero distortion conditions the phase at each level of the 3-level chrominance test signal should be 90 degrees relative to the phase of the color burst as shown in Figure 25A. The phase of the three levels of the test signal should be measured relative to the phase of the color burst. The peak-to-peak variation of the phase of the 3-level chrominance test signal is the difference between the largest and smallest readings obtained. An example of chrominance nonlinear phase distortion is shown in Figure 25B. The above measurement procedure should be repeated using the same test signal transmitted with 10% APL and then tested with 90% APL. This standard applies to all values of APL from 10% to 90%.

NOTE: Chrominance nonlinear phase distortion is an out-of-service measurement when APL is utilized in the performance of this measurement.

5.1.2.7 Dynamic Gain of the Picture Signal.

5.1.2.7.1 **Definition.** Dynamic gain of the picture signal of a transmission service channel is the change in transmission service channel insertion gain as measured by the change in the peak-to-peak luminance level resulting from variations in APL.

5.1.2.7.2 Standard Value. The standard value for one coding is ≤x IRE units.

5.1.2.7.3 Method of Measurement. Dynamic gain of the picture signal is an out-of-service test. A multisignal waveform, which uses a composite test signal combined with a flat-field signal shown in Figure 26, shall be used to measure dynamic gain of the picture signal. The composite amplitude of the test signal at each APL setting (10%, 50% and 90%) must be checked at the sending end prior to the commencement of the test. The test signal shall be applied to the transmission service channel input terminals. The waveform monitor at the receiving end shall be properly calibrated.

The composite test signal shall be observed at the transmission service channel output terminals for a change in line-bar amplitude when the input signal APL is varied. The peak-to-peak variation of the line-bar level for the three APL's, expressed in IRE units, is the dynamic gain of the picture signal.

5.1.2.8 Dynamic Gain of the Synchronizing Signal.

5.1.2.8.1 Definition. Dynamic gain of the synchronizing signal is a change in transmission service gain as measured by the change in the synchronizing pulse peak-to-peak amplitude resulting from variations in APL.

5.1.2.8.2 Standard Value. The standard value for one coding is ≤x IRE units.

5.1.2.8.3 Method of Measurement. Dynamic gain of the synchronizing signal is an out-of-service test. A multisignal waveform, which uses a composite test signal combined with a flat-field signal shown in Figure 26, shall be used to measure dynamic gain of the synchronizing signal. The amplitude of the composite test at each APL setting (10%, 50% and 90%) must be checked at the sending end prior to the commencement of the test. The waveform monitor at the receiving end shall be properly calibrated. The test signal shall be applied to the transmission service channel input terminals.

The test signal shall be observed for a change in the synchronizing pulse level at the transmission service channel output terminals when the signal APL is varied. The peak-to-peak variation of the synchronizing pulse level for the three APL's, expressed in IRE units, is the dynamic gain of the synchronizing signal.

5.1.2.9 Transient Synchronizing Signal Nonlinearity.

5.1.2.9.1 Definition. Transient synchronizing signal nonlinearity of a transmission service channel is the departure from equality in the amplitude of the synchronizing pulse tip to blanking level portion of a composite picture signal when the APL is varied abruptly between high and low values. It is measured at the transmission service channel output terminals.

5.1.2.9.2 Standard Value. The standard value for one coding is ≤x IRE unit.

5.1.2.9.3 Method of Measurement. Transient synchronizing signal nonlinearity is an out-of-service test. A flat-field signal superimposed upon standard synchronizing and blanking signals shall be applied to the transmission service channel input terminals. The signal shown in Figure 7 shall be switched between 10% and 90% APL. The APL transitions shall be made in less than 10 microseconds and at intervals not less than five times the settling time of any accompanying transient.

The test signal with alternating APL applied at the input terminals shall be observed at the transmission service channel output terminals on a suitable slow-sweep oscilloscope or waveform monitor. The test signal with alternating APL applied shall be connected through the differentiating network shown in Figure 22A for observation. The waveform monitor should be adjusted to present a highest synchronizing pulse amplitude of 100 IRE units (10% or 90% APL). The envelope of the pulses representing the synchronizing signal's rise, as viewed at slow-sweep speed, will show the transient synchronizing signal nonlinearity. The transient distortion is recorded in IRE units relative to the largest amplitude of the synchronizing signal displayed.

A photograph of the waveform monitor may aid in determining transient synchronizing signal nonlinearity.

5.1.2.10 Signal-to-Low-Frequency-Noise Ratio (0-10 kHz).

5.1.2.10.1 Definition. The signal-to-low-frequency-noise ratio of a transmission service channel is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally 0.714 volt = 100 IRE units), to the peak-to-peak low-frequence-noise voltage. *Low-frequency noise* as used here includes all frequencies below 10 kHz and will generally have its source in power supplies. Synchronizing signals are not included in the signal measurement. It is measured at the transmission service channel output terminals.

5.1.2.10.2 Standard Value. The standard value for one coding is $\geq$x dB.

5.1.2.10.3 Method of Measurement. The video signal-to-low-frequency-noise ratio measurement may be an in or out-of-service test. The transmission service channel shall be operated at standard input and output levels and terminated in a standard load impedance. A peak-to-peak noise reading instrument containing the proper band-limiting network (shown in Figure 27B-Low Pass) shall be connected to the transmission service channel output terminals.

The signal-to-low-frequency-noise ratio in dB is computed using the following formula with values in IRE units:

$$\text{Signal-to-Low-Frequency-Noise Ratio (dB)} = 20 \log_{10} \frac{\text{P-P Luminance Signal Amp.}}{\text{P-P Low Frequency Noise Amp.}}$$

5.1.2.11 Signal-to-Periodic-Noise-Ratio (300 Hz - 4.2 MHz).

5.1.2.11.1 Definition. Signal-to-periodic-noise interference of a transmission service channel is the term applied to an interference that consists of a single frequency or a number of single-frequency components. The signal-to-periodic-noise ratio is the ratio of the peak-to-peak luminance signal (blanking to reference white, nominally 0.714 volts = 100 IRE units), to the peak-to-peak value of the periodic noise. Periodic noise as used here means any frequency between 300 Hz - 4.2 MHz. It is measured at the transmission service channel output terminals.

5.1.2.11.2 Standard Value. The standard value for one coding is $\geq$xx dB.

5.1.2.11.3 Method of Measurement. Signal-to-periodic-noise ratio is an out-of-service measurement. The flat-field test signal shown in Figure 7A shall be used when measuring periodic noise. The amplitude of the test signal is adjusted to 100 IRE units at the sending end prior to commencement of the test. The test signal shall be applied to the transmission service channel input terminals. The amplitude of the bar portion of the test signal shall be adjusted to 100 IRE units at the transmission service channel output terminals. The peak-to-peak amplitude of periodic noise (300 Hz - 4.2 MHz) should be measured in IRE units. Examples of periodic noise interference are shown in Figure 28.

Alternately, the video input signal is removed and the band is swept with a selective volt meter or spectrum analyzer of sufficiently narrow bandwidth to measure the amplitude of any interfering tones.

The signal-to-periodic-noise ratio in decibels is computed using the following formula:

$$\text{Signal-to-Periodic Noise (dB)} = 20 \log_{10} \frac{\text{0.714 Volt}}{\text{P-P of Per. Noise Amp.}}$$

5.1.2.12 Signal-to-Chroma-Weighted-Noise Ratio.

5.1.2.12.1 Definition. Signal-to-chroma-weighted-noise ratio is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally 0.714 volt = 100 IRE units), to the chroma weighted RMS noise level. The noise affecting the chrominance portion of the signal occurs in the frequency range between 2.6 MHz and 4.2 MHz and has both an amplitude and phase component.

5.1.2.12.2 Standard Value.

Signal-to-Chroma-Weighted-Noise Ratio

Type	SNR
AM	$\geq$ x dB
PM	$\geq$ x dB

5.1.2.12.3 Method of Measurement. The video signal-to-chroma-weighted-noise ratio measurement is an out-of service test. The transmission service channel shall be operated at standard input and output levels and terminated in a standard load impedance. A flat full field red test signal shall be applied to the input of the transmission service channel. A chrominance noise meter shall be connected to the transmission service channel output terminals. The signal-to-noise ratio in dB of both components is read from the instrument.

5.1.3 Video Signal Additive Noise Distortion.

5.1.3.1 Signal-to-Weighted-Random-Noise Ratio (10 kHz - 4.2 MHz).

5.1.3.1.1 Definition. The signal-to-weighted-noise is the ratio of the peak-to-peak luminance signal, blanking to reference white (nominally 0.714 volt = 100 IRE units), to the weighted RMS noise level. The noise referred to is both thermal and quantizing noise in the 10 kHz - 4.2 MHz range. Synchronizing signals are not included in the signal measurement. It is measured at the transmission service channel output terminals.

5.1.3.1.2 Standard Value. The standard value for one coding is $\geq$x dB.

5.1.3.1.3 Method of Measurement. The video signal-to-weighted-noise ratio measurement may be an in or out-of-service test. The transmission service channel shall be operated at standard input and output levels and terminated in the standard load impedance. A true noise reading instrument containing the proper band-limiting and weighting networks (shown in Figures 27A, 27B-High Pass and 27C) shall be connected to the transmission service channel output terminals. The signal-to-weighted-noise ratio in dB is computed using the following formula with values expressed in volts:

$$S/N_W \text{ Ratio (dB)} = \log_{10} \frac{\text{P--P Luminance Signal Amp.}}{\text{RMS Weighted Noise}}$$

Where

S = Signal
N_W = Weighted Random Noise

5.1.4 Video Signal Distortion Associated with Quantising.

5.1.4.1 Signal to Quantising Noise.

5.1.4.1.1 Definition.

5.1.4.1.2 Standard Value.

5.1.4.1.3 Method of Measurement.

5.1.4.2 Granular Noise.

5.1.4.2.1 Definition.

5.1.4.2.2 Standard Value.

5.1.4.2.3 Method of Measurement.

5.1.4.3 High Amplitude Jitter.

5.1.4.3.1 Definition. High amplitude jitter is the variation in amplitude associated with transitions having high-frequency spectral content.

5.1.4.3.2 Standard Value.

5.1.4.3.3 Method of Measurement. High amplitude jitter is an out-of-service test using a full field composite test signal of Figure 3. The peak-to-peak variations of the 2T pulse with time is used to determine this distortion.

5.1.4.4 Loss of Detail.

5.1.4.4.1 Definition. Loss of detail is the change in resolution as a result the equipment used to provide the transmission service channel.

5.1.4.4.2 Standard Value.

5.1.4.4.3 Method of Measurement.

5.1.4.5 Edge Busyness.

5.1.4.5.1 Definition. Edge Busyness is the variation in apparent timing of a step function signal, such as a line-bar, resulting from the signal processing equipment employed to provide the transmission service channel.

5.1.4.5.2 Standard Value.

5.1.4.5.3 Method of Measurement.

5.1.4.6 Time Base Error.

5.1.4.6.1 Definition. Time-base Error is the variation in timing of the picture signal at the output relative to that supplied to the input of the transmission service channel.

5.1.4.6.2 Standard Value.

5.1.4.6.3 Method of Measurement.

5.1.4.7 Phase Jitter.

5.1.4.7.1 Definition. Phase jitter is the phase instability of the color subcarrier.

5.1.4.7.2 Standard Value.

5.1.4.7.3 Method of Measurement.

5.1.4.8 Slope Overload.

5.1.4.8.1 Definition. Slope overload is the change in rising time of a step change in luminance signal level.

5.1.4.8.2 Standard Value.

5.1.4.8.3 Method of Measurement.

5.1.4.9 Subcarrier to Horizontal (SCH) Phase Error.

5.1.4.9.1 Definition. Subcarrier to horizontal (SCH) phase error is the variation in alignment between the zero crossing of the extrapolated subcarrier of color burst and the fifty percent point of the leading edge of the horizontal sync pulse.

5.1.4.9.2 Standard Value. The output SCH should track the input SCH within $\pm$ x Degrees and should be time invariant.

5.1.4.9.3 Method of Measurement. The subcarrier-to-horizontal phase error is an out of service test using the composite test signal shown in Figure 5. The test signal from a calibrated source shall be applied to the transmission service channel input terminal. The test signal at the transmission service channel output shall be connected to a SCH test set. The SCH test is measured in degrees. Vary the SCH at the input over a $\pm 40^{\circ}$ range and assure that the signal at the output tracks within $\pm x^{\circ}$.

5.1.5 Motion Video Distortion.

5.1.6 Availability of Video Service. (For further study.)

5.2 Audio Signal Performance.

5.2.1 Amplitude Response versus Frequency.

5.2.1.1 Definition. The audio amplitude response versus frequency of a transmission service channel is the amplitude variation as a function of audio frequency. The amplitude variation is expressed in dB.

5.2.1.2 Standard Value. The amplitude response versus frequency shall not exceed the standard values presented in Table 3 and Figure 29.

Table 3. Amplitude Response versus Frequency for 7.0-kHz Service

Frequency Range	Response Limits
50 to 250 Hz	+0.3 dB to -1.0 dB
251 to 7000 Hz	+0.3 dB to -0.3 dB

NOTE: Reference to a nominal 400 Hz.

5.2.1.3 Method of Measurement. The measuring equipment shall terminate the input and the output of the transmission service channel under test in standard source and load impedances as specified in 4.3.1.1 and 4.3.1.4. The balanced-to-ground connection shall be maintained. A sequence of sinusoidal signals at various frequencies within the service channel bandpass shall be applied, maintaining the input level for each signal at 0 dBm. The transmission service channel output level shall be measured and recorded. The output level of the signal at each frequency is compared with the nominal 400-Hz level.

5.2.2 Total Distortion (TD).

5.2.2.1 Definition. Total distortion (TD) of a transmission service channel is the distortion of a sinusoidal signal after it has passed through a transmission service channel that causes the generation of components harmonically related to the input sinusoid plus noise produced by the channel.

Total distortion is a measure of the undesired output of a transmission service channel. Undesired output includes disturbances such as quantizing noise, aliasing noise, power supply noises and random noises. Also included are harmonic distortion, and spurious tones. The desired signal is the single-frequency test-tone component at the channel output resulting from the channel input signal. Total distortion is computed by combining undesired signal components on a root-sum-squared (R.S.S.) power-law basis and expressing those combined components as a percentage of the undesired signal level to the desired signal level.

$$\text{Total Distortion (\%)} = \frac{\text{Undesired Signal (Volts)}}{\text{Desired Signal (Volts)}} \times 100$$

5.2.2.2 Standard Value. The standard value of TD at a nominal 400 Hz shall not exceed the values shown in Table 5.

Table 5. Total Distortion

Service	TD	
7 kHz	x%	(Signal-to-Total-Distortion ratio ≥ x dB)

NOTE: Measured at 0 dBm, nominal 400 Hz. See Figure X for filter response.

5.2.2.3 Method of Measurement. The measuring equipment shall terminate the transmission service channel output terminals in a standard impedance as specified in 4.4.1.4. Using a signal generator having an internal impedance as specified in 4.4.1.1., a 0 dBm, nominal 400 Hz test signal, with a total distortion an order of magnitude better than the limit to be measured is applied to the transmission service channel input. The 7.0 kHz band-limited transmission service channel output is measured employing a notch filter (at a 400 Hz with at least 20 dB more loss than the expected signal-to-total distortion ratio limit). Some distortion analyzers read percent directly; however, for others a signal-to-total-distortion ratio is determined at by first measuring the signal power output without nulling and then measuring the total distortion power output with nulling.

5.2.3 Band-limited Signal-to-Idle-Channel-Noise Ratio (BLSICNR).

5.2.3.1 Definition. The band-limited signal-to-idle-channel-noise ratio (BLSICNR) of a transmission service channel is the ratio of peak operating level to the rms noise level at the transmission service channel output terminals. Noise is any extraneous output signal in the frequency band from 20 Hz to 7.0 kHz. The idle-channel noise is the noise power contained in the bandpass of the audio transmission channel as measured through a 7.0-kHz flat band-limiting network. See Figure 31 for filter response.

5.2.3.2 Standard Value. The standard values of the band-limited signal-to-idle-channel-noise ratio shall be greater than XX dB.

5.2.3.3 Method of Measurement. The measuring equipment shall terminate the transmission service channel output terminals in a standard impedance as specified in 4.4.1.4. Using a signal generator having an internal impedance as specified in 4.4.1.1., a 0 dBm, nominal 400 Hz test signal shall be applied to the transmission service channel input terminals and the transmission service channel output signal amplitude shall be measured. The 400-Hz signal shall be removed from the input to the transmission service channel and the input shall be terminated in a standard source impedance. The noise of the transmission service channel shall be measured connecting the output of the transmission service channel through the 7-kHz band-limiting network shown in Figure X and terminated in an rms-indicator. Compute the band-limited signal-to-idle channel-noise ratio using the following formula:

Band-limited signal-to-idle channel-noise ratio (dB) = Received signal level minus idle channel noise level (where the signals are measured in dBm).

5.2.4 Gain.

5.2.4.1 Definition. The audio signal gain of a transmission service channel is the ratio of a transmission service channel's output signal level to its input signal level.

5.2.4.2 Standard Value. The standard value over the life of service shall not exceed 0 ± XX dB.

5.2.4.3 Method of Measurement. The measuring equipment shall terminate the output of the transmission service channel under test in a standard impedance as specified in 4.4.1.4. The balanced-to-ground connection shall be maintained. Using a signal generator having an internal impedance as specified in 4.4.1.1., a 0 dBm, nominal 400 Hz test signal shall be applied to the input of the transmission service channel and the signal level measured at the transmission service channel output. The equation to determine gain is as follows:

$$\text{Gain (dB)} = 10 \log_{10} \frac{\text{output power}}{\text{input power}}$$

5.2.5 Discernible Crosstalk Discernible crosstalk of a transmission service channel is the unwanted coupling of the signal from other transmission service channel(s) into the desired channel.

5.2.5.1 Standard Value. No intelligible tones or parts of conversations shall be detected at the idle-channel-noise floor as referenced in 5.2.4.2.

5.2.5.2 Method of Measurement. A listening test should be made for 10 minutes with an acoustical monitoring device attached to the output of the transmission service channel. The monitoring device should be at least the bandwidth of the service and should be band limited to 7.0 kHz. The monitoring device should also have sufficient gain such that the noise floor can be monitored at a comfortable level. Unwanted tones or programming detected by the monitor receiver indicates a crosstalk problem.

5.2.6 Output Level Tracking.

5.2.6.1 Definition. Output level tracking is a measure of accuracy of the transmission service channel in reproducing a specific change in amplitude of a signal applied to the input.

5.2.6.2 Standard Value. The output level shall track within the limits as specified in Table 12 for a 10-dB step of the input level.

NOTE: This X dBm level applies to a nominal 400-Hz test signal.

Table 12. Output Level Tracking Limits

Service	Variation
7 kHz	± 0.X dB

5.2.6.3 Method of Measurement. A nominal 400-Hz test signal shall be applied at 0 dBm to the input of the transmission service channel. The level at the output of the channel shall be determined. The input test signal shall be decreased by 10 dB and the signal level shall be observed at the output. The signal level shall be returned to 0 dBm and then the input test signal shall be increased by an additional X dB and the signal level shall be observed at the output. At each level extreme the tracking variation shall not exceed the standard.

5.2.7 Quantizing Error.

5.2.7.1 Definition. An error caused by conversion of a variable having a continuous range of values to a quantized form having only discrete values, as in an analog to digital conversion. The error is the difference between the original (analog value) and its quantized (digital) representation.

5.2.7.2 Standard Value. The maximum value for quantizing error shall not exceed the standard values presented in table below:

Table 13. Quantizing Error

Low-level tests	Service		Limit (ΔQ_a)
	7 kHz		x dB change max.
High-level tests	**Service**	**200-Hz Limit**	**4-kHz Limit**
	7 kHz	-x dBm	-x dBm

Note: High-level test weighted and relative to x dBm

5.2.7.3 Method of Measurement. The quantizing error measurements are divided into low- and high-signal-level tests. The low-level tests expose problems due to non-uniform quantization steps or lack of proper input dither. The high-level tests determine the degree that program modulated quantizing error produces an audible impairment.

Low-Level Test. This test determines the biggest change in the 1/3 octave bands between 1 kHz and 7.0 kHz when a small signal is applied. To perform this test a low-distortion oscillator using a standard output impedance is adjusted to 400 Hz at -15 dBm into a standard load impedance. Remove the oscillator from the load. Connect the oscillator to the input of the transmission service channel, a distortion analyzer to the output of the transmission service channel with a 1/3 octave analyzer with class II or III band-pass filters (ANSI S1.11-1966) connected to the distortion analyzer output. The distortion analyzer is used to determine the absolute value of the idle-channel noise and the noise-distortion spectrum with the signal present. The absolute spectra levels, with and without signal are compared band by band from 1 kHz to 7.0 kHz and the absolute value of the maximum difference in dB taken to be representative of the audible modulation of the noise floor.

High-Level Test. A low-distortion oscillator using a standard output impedance is adjusted to either 200 Hz at +8 dBm or 4 kHz at 0 dBm into a standard load impedance. Connect the oscillator to the input of the transmission service channel and a distortion analyzer to the output of the transmission service output with one of two weighting networks.

The 200-Hz weighting network should be the series combination of a 3-pole Butterworth high-pass filter at 2 kHz and a 2-pole Butterworth low-pass filter at 3.5 kHz. The gain is calibrated to produce the same resultant level as an unweighted 20-kHz bandwidth measurement of a white noise floor and is adjusted to be 7.25 dB at 2 kHz.

The 4-kHz weighting network should be the cascade of three first-order high-pass filters at 180 Hz in series with a second-order Butterworth low-pass filter at 2500 Hz. The gain is adjusted to produce the same resultant level as an unweighted 20-kHz bandwidth measurement of a white noise floor and is 7.95 dB at 2 kHz.

The distortion analyzer should either have the provision of inserting the weighting networks after the notch filter before the measuring meter or be able to function with the lower level signals that occur if the weighting networks are inserted before the distortion analyzer. In either case the weighted distortion should be expressed relative to x dBm.

5.2.8 Intermodulation Distortion.

5.2.8.1 Definition. Intermodulation distortion can be broadly defined as the generation of undesirable signal components from the mixing of input signal components within the transmission service channel.

5.2.8.2 Standard Value. The maximum value of intermodulation distortion shall not exceed the standard values of X%.

5.2.8.3 Method of Measurement. A generator simultaneously producing test signals of 0.8 kHz and 1.42 kHz each at x dBm is connected to the input of the transmission service channel. The output of the transmission service channel is terminated in the correct load impedance as referenced in 4.3.1.4 with a frequency selective rms-meter. The level of the third order difference tone at 0.18 kHz is measured.

5.2.9 Transient Response.

5.2.9.1 Definition. The transient response of a service channel is defined as the output waveshape which results from a suddenly applied voltage at the input to the service channel. The transient characteristic is limited by the ability of the service channel to transmit both high- and low-frequency signals simultaneously without distortion. The high-frequency response will determine the shape of the transient for a short time after the application, and the low-frequency response will determine the waveshape after a longer time has elapsed. Damping is indicated by the shape at the top of the waveform.

5.2.9.2 Standard Value. The limits for transient response for all services are under study.

5.2.9.3 Method of Measurement. The method of measurement for transient response is under study.

5.2.10 Envelope Delay Distortion.

5.2.10.1 Definition. Envelope delay distortion is the difference between the envelope delay as a function of frequency and the minimum value of envelope delay.

5.2.10.2 Standard Value. The maximum value for envelope delay shall not exceed the standard values presented below.

Table 15. Envelope Delay Distortion for 7-kHz Service

Frequency	Range	Envelope Delay Distortion (milliseconds)
50 to	100 Hz	x
101 to	200 Hz	x
201 to	7,000 Hz	x

5.2.10.3 Method of Measurement. Connect a generator and a receiver conforming to CCITT Recommendation 0.81 to the transmission service channel. Run the test sequence.

5.2.11 Availability of Audio Service. (For further study)

5.3 Performance Parameters Summary Tables. Performance parameters for 7 kHz is summarized in Table X.

FIGURES

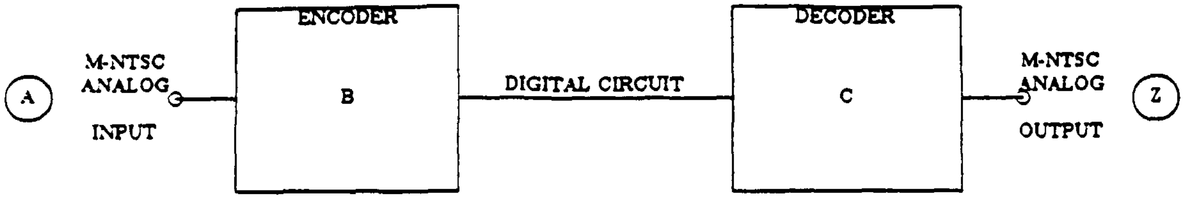

Figure 0. Block Diagram of Digital Transmission Service Channel with Interfaces

This figure contains graphics that are not currently available in this processed version. The graphics can be found as Figure 1 of the T1Q1.5/87-041 document.

Figure 1. Standard Video Signal General Waveform Terminology - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 2 of the T1Q1.5/87-041
document.

Figure 2. IRE Unit Scale

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 3 of the T1Q1.5/87-041
document.

Figure 3. Composite Test Signal - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 4 of the T1Q1.5/87-041
document.

Figure 4. Combination Test Signal - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 5 of the T1Q1.5/87-041
document.

Figure 5. Video Test Signal - Multipulse

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 6 of the T1Q1.5/87-041
document.

Figure 6. Video Test Signal - Field-Bar

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 7 of the T1Q1.5/87-041
document.

Figure 7. Video Test Signal - Flat-Field With Variable APL

This figure contains graphics that
are not currently available in this processed version.
The graphics are not available at this time.

Figure 8. Video Test Signal - Superstreaking

This figure contains graphics that
are not currently available in this processed version.
The graphics are not available at this time.

Figure 9. Video Test Signal - Line Ramp

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are not currently available in this processed version.
The graphics are not available at this time.

Figure 10. Video Test Signal - Modulated-Line Ramp

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are not currently available in this processed version.
The graphics are not available at this time.

Figure 11. Video Test Signal - Modulated Field-Ramp

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are not currently available in this processed version.
The graphics are not available at this time.

Figure 12. Video Test Signal - Field-Ramp

This figure contains graphics that
are not currently available in this processed version.
The graphics are not available at this time.

Figure 13. Video Test Signal - Shallow-Ramp

This figure contains graphics that
are not currently available in this processed version.
The graphics are not available at this time.

Figure 14. Video Test Signal - Resolution

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 8A of the T1Q1.5/87-041
document.

Figure 15. Impedance Reference - Unbalanced to Ground

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 1 of the T1Q1.5/87-031R2
document.

Figure 16. Impedance Reference - Balanced to Ground

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 2 of the T1Q1.5/87-031R2
document.

Figure 17. Nonsymmetrical Test Waveform - Audio

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 10 of the T1Q1.5/87-041
document.

Figure 18. One Coding Amplitude Response versus Frequency Characteristic - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 13 of the T1Q1.5/87-041
document.

Figure 19. Chrominance-to-Luminance Delay Inequality Nomogram - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 14 of the T1Q1.5/87-041
document.

Figure 20. Short-Time Waveform Distortion Measurement (SD) Graticule - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 15 of the T1Q1.5/87-041
document.

Figure 21. Long-Time Waveform Distortion Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 16A of the T1Q1.5/87-041
document.

Figure 22A. Differentiating Network Circuit Diagram - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 16B of the T1Q1.5/87-041
document.

Figure 22B. Luminance Nonlinearity Distortion Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics are similar to those of Figure 17A of the
T1Q1.5/87-31 document but will contain intentional steps.

Figure 23A. Vectorscope Display of Differential Phase with Zero Distortion Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics are similar to those of Figure 17B of the
T1Q1.5/87-041 document but will not contain intentional steps.

Figure 23B. Vectorscope Display of Differential Phase with Distortion at 50% APL Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 18A of the T1Q1.5/87-041
document.

Figure 24A. Chrominance-to-Luminance Intermodulation with Zero Distortion Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 18B of the T1Q1.5/87-041
document.

Figure 24B. Chrominance-to-Luminance Intermodulation with Distortion Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 19A of the T1Q1.5/87-041
document.

Figure 25A. Vectorscope Display of Chrominance Nonlinear Phase with Zero Distortion

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 19B of the T1Q1.5/87-041
document.

Figure 25B. Vectorscope Display of Chrominance Nonlinear Phase with Distortion

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 20 of the T1Q1.5/87-041
document.

Figure 26. Dynamic Gain Distortion of the Picture Signal Composite Test Signal with Flat-Field Overlay Example - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 21A of the T1Q1.5/87-041
document.

Figure 27A. Noise Measurement Filter - Low-Pass 4.2 MHz

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 21B of the T1Q1.5/87-041
document.

Figure 27B. Noise Measurement Filter - Combination 10-kHz High-Pass/Low-Pass - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 21C of the T1Q1.5/87-041
document.

Figure 27C. Noise Measurement Filter - Weighting - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 22 of the T1Q1.5/87-041
document.

Figure 28. Signal-to-Periodic Noise Examples - Video

This figure contains graphics that
are not currently available in this processed version.
The graphics can be found as Figure 4 of the T1Q1.5/87-031R2
document.

Figure 29. Amplitude Response versus Frequency for 7-kHz Service.

This figure contains graphics that are not currently available in this processed version. The graphics can be found as Figure 6 of the T1Q1.5/87-031R2 document.

Figure 31. Unweighted Measurement Filter Response

APPENDIX

GLOSSARY

Exchange Carrier (EC).

The telecommunications common carrier franchised to provide telecommunications services within one or more exchanges. An EC may also provide exchange access service, intra-LATA long-distance service, and in some unusual cases, inter-LATA service.

Interexchange Carrier (IC).

A telecommunications common carrier authorized to provide telecommunications services between LATAs. An IC may also provide service within some LATAs.

Local Access and Transport Area (LATA).

A geographic area established for the provision and administration of telecommunications services. A LATA encompasses one or more exchanges that have been grouped to serve common social, economic, and other purposes.

Network Interface (NI).

The point of demarcation between the carrier's facilities and the customer's installation which establishes the technical interface and division of operational responsibility.

Point of Termination (POT).

The point of demarcation between carriers which establishes the technical interface and division of operational responsibility.

Video Test Signal - Field Bar.

The field-bar test signal shown in Figure 6, consists of a field-rate square wave, extending to the total luminance signal level (100 IRE units), superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Field Ramp.

The field ramp test signal shown in Figure 2, consists of a linear luminance ramp varying form 0 IRE to 100 IRE units superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Flat Field with Variable APL.

The flat-field test signal with variable APL shown in Figure 7, consists of a uniform luminance signal, whose average picture level (APL), is transitioned between 10 percent and 90 percent and is superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Line Ramp.

The line-ramp test signal shown in Figure 9, consists of a linear ramp varying from 0 IRE to 100 IRE units superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Modulated Field Ramp.

The modulated field-ramp test signal shown in Figure 11, consists of a linear luminance ramp varying form 0 IRE to 100 IRE units modulated by the color subcarrier signal having a peak-to-peak amplitude of 40 IRE units superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Modulated Line Ramp.

The modulated line-ramp test signal shown in Figure 10, consists of a linear luminance ramp varying from 0 IRE to 100 IRE units modulated by the color subcarrier signal having a peak-to-peak amplitude of 40 IRE units superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Multipulse.

The multipulse test signal shown in Figure 5 consists of a white flag, a 2T pulse and modulated pulses. The modulating frequencies of the pulses correspond to the burst packets of the multiburst test signal (with the exception of 0.5 MHz) superimposed upon standard synchronizing and blanking signals.

Video Test Signal - Resolution.

The resolution test signal is a full field signal that can be used to measure the horizontal, vertical, and diagonal resolution of the picture.

Video Test Signal - Shallow Ramp.

The shallow ramp test signal shown in Figure 13, consists of a linear ramp with a slope of 5 IRE units that may be positioned between 0 and 100 IRE units superimposed upon standard synchronizing and blanking signals.

Dynamic Test Signals.

Dynamic test signals are used to measure horizontal, vertical, diagonal and temporal resolutions effects.

Video Test Signal - Superstreaking.

A full field test signal as shown in Figure 8.

ITEMS UNDER STUDY

APPENDIX B

COMMITTEE T1Q1.5
CONTRIBUTION

****

PROJECT TITLE: VIDEO TELECONFERENCING END-TO-END USER PERFORMANCE STANDARDS (56Kbps to 1.544mbps)

****

CONTRIBUTION TITLE: A TAPE CONTAINING A RANGE OF VIDEOPHONE SCENES

****

SOURCE: DELTA INFORMATION SYSTEMS, INC.
HORSHAM BUSINESS CENTER,
300 WELSH ROAD, BLDG. 3
HORSHAM, PENNSYLVANIA 19044
USA

****

DATE: NOVEMBER 12, 1987

A TAPE CONTAINING A RANGE OF VIDEOPHONE SCENES

The purpose of this contribution is to

1) describe alternative locations of videophone equipment in the office.
2) describe a video tape containing 9 brief scenes which cover a wide range of videophone locations and camera fields of view
3) stimulate thought to be sure that the mx 56/64 Kbit/s codec is designed for the most representative videophone scene(s).

OFFICE LAYOUT

It is expected that initially videophone facilities will be limited to top-echelon executives but, once their utility has been proven, they will rapidly proliferate to middle-level personnel and beyond. Therefore, it is wise to consider various office sizes and arrangements. It is assumed that in most cases the camera and monitor will be co-located to form a single videophone terminal. Three potential office layouts are shown on Figure 1.

The layout shown on top is primarily applicable to a rather spacious executive office. There is plenty of room in front of the desk for a camera and mid-size monitor, either in a fixed location against a wall or on a movable pedestal. After selection of a camera position and desired view of the person in the picture and consideration of the office light level, a suitable lens can be selected. Normally this will be a fixed focal length lens though in a few exceptional cases a remotely controlled zoom lens may be justified.

The middle layout shows the camera videophone terminal located directly on the desk. This setup is inherently less flexible from the standpoint of field of view. This layout has the advantage of being rather universal,independent of the office layout. All offices have desks. The videophone terminal can be highly standardized and therefore produced in large quantity.

The bottom of Figure 1 shows a different but frequently found office arrangement. The desk is placed directly against the wall and a work table is located behind the office occupant. The videophone terminal is mounted on this table. When using the videophone the office occupant turns around exactly as if he was talking to a person sitting at his table. It is unlikely that anything but a fixed focal length lens will be used in this setup.

An important parameter is the field of view covered by the camera. The requirements for this may differ rather widely for various applications, from a limited head and shoulders view of a person to coverage of the whole desk top. The customary descriptions of these views are "close-up" and "wide angle" but these designations are much too vague and can cover many different situations.

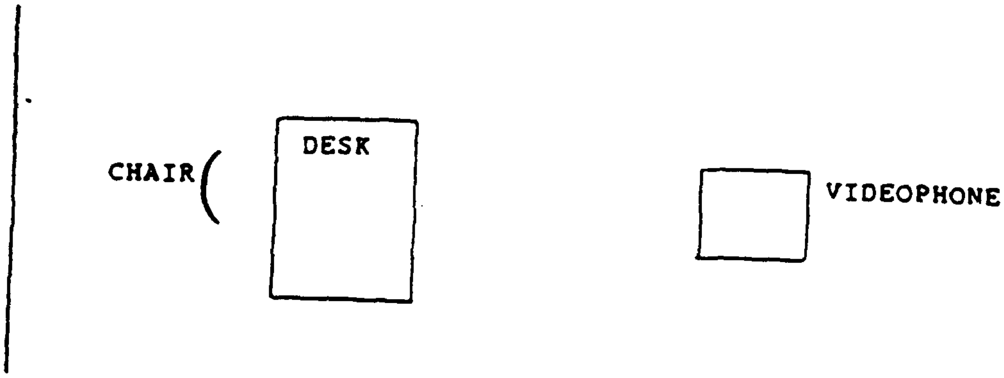
On the other hand, a firm numerical definition can be made by measuring the angles of the width and/or height of the field of view. This parameter, though technically excellent, is rather intangible and non-descriptive from a practical point of view and requires special measurements and calculations. Therefore, the practical parameter used here is to express the picture width in the number of shoulder widths of the person shown. Though this is an estimate rather than an exact measurement it defines the field of view in a straightforward manner directly related to the videophone application.

The Videophone Scenes Tape was prepared in a TV production studio under staged optimized conditions. A zoom lens could easily simulate any actual office environment. The height of the camera lens above the floor was 117 cm for scenes 1 to 4 and 7 to 9, putting it approximately at eye level of the person at the desk, while for scenes 5 and 6 it was lowered to 86 cm, putting it just 12 cm above the desk top.

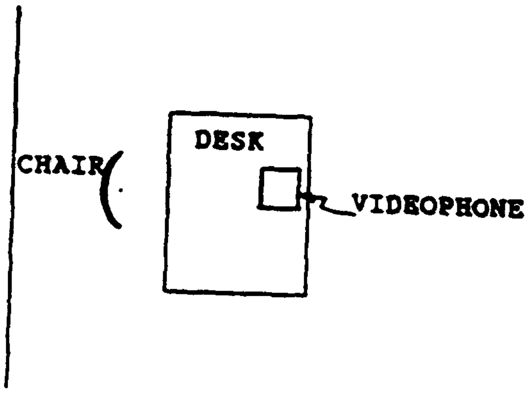
TAPE CONTENTS

The tape consists of 9 scenes, covering the three different layouts described above. Table 1 summarizes the key parameters for each scene. Different combinations of the field of view and type of action are provided. An additional parameter listed is the visibility of the desk top which can be important in the discussion of printed or written material.

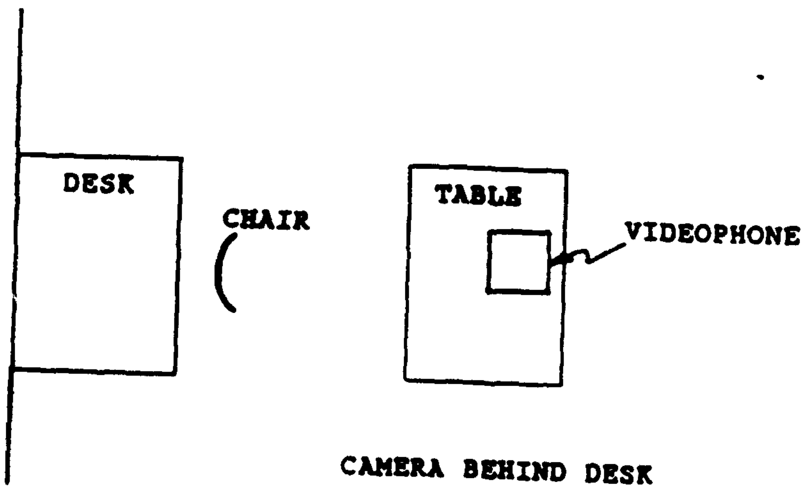
Excluding the color bars at the beginning, the total length of the tape is about 10 minutes. The lengths of each scene are variable but average about 1 minute.



CAMERA IN FRONT OF DESK



CAMERA ON DESK



CAMERA BEHIND DESK

FIGURE 1 VIDEOPHONE OFFICE LAYOUTS

SCENE NO.	CAMERA LOCATION	ACTION	FIELD OF VIEW (SHOULDER WIDTHS)	DESK TOP VISIBILITY
1	FRONT OF DESK	TELEPHONE CALL	5	MOST
2	FRONT OF DESK	EQUIPMENT DEMONSTRATION	3	LESS THAN HALF
3	FRONT OF DESK	TELEPHONE CALL	2	LITTLE
4	FRONT OF DESK	MAGAZINE ARTICLE DISCUSSION	1.2	NONE
5	ON DESK	EQUIPMENT DEMONSTRATION	1.5	NONE
6	ON DESK	SALES TALK	1	NONE
7	BEHIND DESK	EQUIPMENT DEMONSTRATION	4	ALL
8	BEHIND DESK	EQUIPMENT DEMONSTRATION	3	MOST
9	BEHIND DESK	EQUIPMENT DEMONSTRATION	1.3	ALMOST NONE

TABLE 1. VIDEOPHONE SCENES TAPE CONTENTS

SUMMARY OF 20 RESPONSES 3-2-88

QUESTIONNAIRE FOR THE

56/64KB/SEC VIDEOPHONE APPLICATION

A. Video Tape Questions

1. Assuming only one person is viewed by the camera in the office, which office layout do you think will be the primary 56/64Kb/sec application; secondary use, etc. Rank 1, 2, 3 in spaces provided below.

Behind desk	0	NO. RESPONSES FOR PRIMARY APPLICATION
Front of desk	10	
On desk	10	
Other	–	

If you marked "other," explain your layout below.

2. Assuming the field of view of the videophone terminal is fixed, and the unit is viewing one person, what do you think the field of view will be in shoulder-widths.

2.0 shoulder-widths

(6 SCORES LOWER, 4 SCORES HIGHER)

3. Which of the nine scenes in the video tape do you think best represents the videophone application?

Scene ________

Do you think this scene well represents the videophone application?

Yes ______

No ______

NO. PERSONS PREFERRING SCENE	SCENE NO.	CAMERA LOCATION	FIELD OF VIEW	CONSISTENCY WITH 1,2
9	3	FRONT	2	VERY GOOD
8	5	ON	1.5	GOOD
3	2	FRONT	3	GOOD

B. General Questions

1. What percentage of the time do you think a videophone terminal in the office will be viewing one person as opposed to multiple persons.

74.5 % one person

2. The table below defines four possible applications for the use of the 64Kbps codec. How do you think these applications will be distributed on a % basis. (early 1990's)

POTENTIAL 64KB/S APPLICATIONS

Purpose		Terminal Location	Typical No Persons per Site	Interactive (I) Broadcast (B)
Videophone		Office	1-2	I
Conference e.g. problem solving		Conference Room	2-6	I
Education	Source	Office/Conf. Room	1	B
	Destination	Classroom	Many	
Videophone		Home	1	I

Videophone Office	38.1
Conference	28.9
Education	22.0
Videophone Home	8.3
Other	2.7
Total	100%

3. In those cases where multiple persons are viewed in the conference room what will the % distribution be for the various number of persons viewed.

2	37 %
3	29 %
4-5	27 %
6 or more	7 %
Total	100 %

4. What percentage of the videophone calls in the office will employ graphics?

48 %

In those calls where graphics are used what percentage will use the basic videophone resolution as opposed to a separate graphics source with higher resolution?

51 % basic videophone resolution

APPENDIX C

COMMITTEE T1
CONTRIBUTION

Document Number: T1Q1.5/89- 103

****

STANDARDS PROJECTS: Analog Interface Performance Specifications for Digital Video Teleconferencing/Video Telephony Service

****

TITLE: SUBJECTIVE TESTS OF VIDEO TELECONFERENCING CODECS

****

ISSUE ADDRESSED: SUBJECTIVE EVALUATION OF CODEC PERFORMANCE AT VARIOUS BIT RATES

****

SOURCE: DELTA INFORMATION SYSTEMS, BY RICHARD SCHAPHORST

****

DATE: 02-07-89

****

DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

****

KEYWORDS: Video, Teleconferencing, Codecs, Test Scores

****

DISCLAIMER:

SUBJECTIVE TESTS OF VIDEO
TELECONFERENCING CODECS

This contribution contains the results of unofficial subjective tests on several video teleconferencing codecs operating at bit rates from 64 to 1544 Kbps. These tests were performed during the meeting of the TIQ1.5 Subworking Group on Video Teleconferencing/Video Telephone in Baltimore, MD. on November 8, 1988. They consisted of the screening of six 3/4" video tapes with identical content which had been processed through video codecs of different bit rates. Three monitors were provided for viewing by members of the Subworking Group who agreed to participate in the tests.

The test tapes contain scenes which are considered typical for several applications of video teleconferencing. There are four segments, one for each application to be evaluated, each divided into two or three parts. The approximate contents of each segment and part are as follows:

Segment 1: Face-to-face Video Teleconference (between offices)

Part 1: Single person, head and shoulders

Part 2: Graphics with motion, zoom and pointing

Segment 2: Group Video Teleconference (between conference rooms)

Part 1: Groups of 3 and 6 persons

Part 2: Groups divided into single and pairs of persons

Segment 3: Tele-Education (instructor to many distant classrooms)

Part 1: Explanation of printed circuit board

Part 2: Drawing on flip chart pad

Part 3: Animated computer graphics, illustration, drawing

Segment 4: Briefing (company executive to branch offices)

Part 1: Animated computer graphics, flow chart

Part 2: Person explaining view graphs and map

Table 1 shows the questionnaire given to the evaluators for each test. Only 3 evaluators considered themselves technical experts but most of them had used video teleconferencing and regarded the experience as favorable. The ratings are in exact accordance with CCIR Recommendation 500-2 which assigns the numbers of 5 to 1 to the excellent to bad ratings. The recommended viewing conditions such as room illumination, monitor brightness and distance were implemented as closely as the meeting room environment would permit but were not ideal. Time constraints made it necessary to make all tests in the shortest possible time with minimal pauses which resulted in a total continuous test time of about 80 minutes which is longer than recommended. The only noticeable effect of these deviations from ideal conditions was the tendency of many evaluators to give higher ratings in later tests.

Three codecs were used for six different tests at data rates of 64, 128, 256, 384, 768 and 1544 Kpbs. The rates were not known to the evaluators and presented in a random sequence. As recommended in CCIR 500-2, most evaluators were not sufficiently expert in video codecs to identify the manufacturers which enhances the validity of the results.

The individual test scores and the results of their numerical evaluation are given on Tables 2 to 7, one for each data rate under test. The scores are first averaged for each evaluator and part of the test tape. Subsequently, averages are computed for each application (segment) and the total for each data rate. Finally, special averages are computed for three predominant tape contents independent of applications, namely Persons (Parts 1-1, 2-1, 2-2, 3-2), Graphics (Parts 1-2, 3-3, 4-1), and combined Persons and Graphics (Parts 3-1, 4-2). The results are shown in curves on Figures 1 to 8.

The test scores show a typical feature of subjective tests, namely wide variations between evaluators. At times an evaluator's scoring may be so erratic that it must be discarded. Also, one part of the test may produce inconsistent results. To check for these eventualities, standard deviations were computed for each line and column on Table 2 to 7. All deviations were low enough to confirm the validity of the results.

The overall range of all average scores extends from 1.5 to 3.5. A rating below 2 is assumed definitely unusable, between 2 and 2.5 marginal but any score above 2.5 should be considered fully usable. Based on these assumptions, a codec operating at 64 Kbps is marginally usable for showing people in a teleconference environment.

Rates of 128 Kbps and above are definitely usable for most applications. 384 Kbps give on the average fair results while the top rate of 1544 Kbps ranks between fair and good. This is the best that can be expected of any codec since some degradation is inevitable.

Pictures of people generally get the highest rating. Graphics become somewhat difficult when motion of the material is involved. The most difficult scenes are the ones showing people together with high detail graphics including camera panning and zooming, as exemplified by Parts 3-1 and 4-2. The same factors cause the briefing segment to be rated much lower than the other three applications which show only small differences. All curves confirm that the picture quality rating increases at higher bit rates. There are a few minor exceptions and they are no more than what must be expected considering the inherent uncertainties of subjective testing.

TEST AND EVALUATION OF VIDEO CODECS

WHEN USED FOR TELECONFERENCING

valuator Name: ______________________________

	YES	NO
. I consider myself a technical expert in digital video teleconferencing.	☐	☐
. I have used video telecconferencing in the past.	☐	☐
. If the answer to No. 2 is yes, has the experience been favorable?	☐	☐

RATINGS

ent .	Application Category	Part No.	Excel.	Good	Fair	Poor	Bad
	Face-to-Face Video Telephone	1					
		2					
	Group Teleconference	1					
		2					
	Tele-education	1					
		2					
		3					
	Briefing	1					
		2					

TABLE 1

ATOR	SEGMENT	1		2		3			4		
	PART	1	2	1	2	1	2	3	1	2	AVERAGE
		3	2	3	2	1	3	2	2	1	2.1
		2	2	2	1.5	1	2	2	2	1	1.7
		2	2	2	2	1	3	2	1	2	1.9
		3	2	2	2	2	2	2	2	2	2.1
		2	1	2	2	1	2	1	2	1	1.6
		3	1	2	2	3	3	3	2	1	2.2
		3	2	3	2	2	3	3	2	2	2.4
		3	2	2	1	1	2	2	2	1	1.8
		3	3	3	3	3	4	3	2	2	2.9
		4	3	2	2	1	3	2	2	1	2.2
		3	2	2	3	2	3	2	3	1	2.3
		2	2	2	2	2	2	3	2	2	2.1
		4	3	3	3	1	3	2	2	1	2.4
		2	2	2	2	2	3	2	2	2	2.1
		2	1	2	2	1	3	2	1	1	1.7
	PART	2.7	2.0	2.3	2.1	1.6	2.7	2.2	1.9	1.4	
	SEGMENT	2.3		2.2		2.2			1.7		
ES	TOTAL	2.1									
	PERSONS	2.4									
	GRAPHICS	2.0									
	PERSONS & GRAPHICS	1.5									

TABLE 2. TEST RESULTS - 64 KBPS

JATOR	SEGMENT	1		2		3			4		
	PART	1	2	1	2	1	2	3	1	2	AVERAGE
	.	1	1	1	1	1	3	2	2	-	1.5
		3	3	3	2.5	3	3	3	3	3	2.9
		2	3	3	2	2	3	3	2	3	2.6
		3	2	2	3	2	2	2	2	2	2.2
		4	1	2	3	1	2	1	1	1	1.8
		-	-	-	4	3	3	3	3	3	3.2
		3	3	3	2	2	3	4	3	3	2.9
		3	2	2	1	2	2	2	2	1	1.9
		3	3	3	3	4	4	3	3	3	3.2
		3	2	2	3	2	3	2	2	1	2.2
		3	2	2	3	2	3	2	3	1	2.3
		3	2	2	2	2	2	2	2	2	2.1
		5	4	4	4	3	4	3	3	1	3.4
		3	2	2	3	2	3	3	2	2	2.4
		2	2	2	2	3	2	2	2	2	2.1
	PART	2.9	2.3	2.4	2.6	2.2	2.9	2.5	2.3	2.0	
	SEGMENT	2.6		2.5		2.6			2.2		
GES	TOTAL	2.4									
	PERSONS	2.7									
	GRAPHICS	2.4									
	PERSONS & GRAPHICS	2.1									

TABLE 3. TEST RESULTS - 128 KBPS

ATOR	SEGMENT	1		2		3			4		
	PART	1	2	1	2	1	2	3	1	2	AVERAGE
		1	2	2	2	1	1	2	2	2	1.7
		4	3	3.5	3.5	4	5	4	2.5	3	3.6
		3	3	3	3	2	4	3	3	3	3.0
		2	2	2	2	1	2	3	2	2	2.0
		2	2	3	2	3	4	3	2	2	2.6
		3	2	3	3	3	3	4	2	2	2.8
		3	2	2	2	1	3	3	3	3	2.4
		4	3	1	1	2	2	3	3	1	2.2
		4	3	3	4	4	4	4	4	3	3.7
		4	2	2	3	2	3	2	3	1	2.4
		3	2	2	3	2	3	2	3	1	2.3
		3	2	2	2	3	3	3	3	2	2.6
		3	2	3	3	3	3	3	3	1	2.7
		3	2	2	3	2	4	3	3	3	2.8
		3	2	3	3	2	3	3	3	2	2.7
	PART	3.0	2.3	2.4	2.6	2.3	3.1	3.0	2.8	2.1	
	SEGMENT	2.6		2.5		2.7			2.5		
GES	TOTAL	2.6									
	PERSONS	2.8									
	GRAPHICS	2.7									
	PERSONS & GRAPHICS	2.2									

TABLE 4. TEST RESULTS - 256 KBPS

ATOR	SEGMENT	1		2		3			4		
	PART	1	2	1	2	1	2	3	1	2	AVERAGE
		2	2	3	3	2	3	2	3	1	2.3
		3	3	4	4	3	4	4	3	3	3.4
		3	4	4	3	3	4	3	2	2	3.1
		3	3	3	3	2	3	3	3	2	2.8
		2	2	3	3	2	3	3	2	2	2.4
		4	4	3	4	3	3	4	3	3	3.4
		3	2	3	3	3	4	3	3	3	3.0
		3	2	3	2	3	3	3	3	2	2.7
		4	4	4	4	4	4	4	4	4	4.0
		4	3	3	3	2	4	3	3	2	3.0
		3	3	2	3	3	4	4	4	2	3.1
		3	3	4	3	3	3	3	4	3	3.2
		4	3	4	3	2	4	3	3	1	3.0
		3	3	3	3	2	3	3	3	2	2.8
		2	2	2	2	2	3	2	2	2	2.1
	PART	3.1	2.9	3.2	3.1	2.6	3.5	3.1	3.0	2.3	
	SEGMENT	3.0		3.1		3.1			2.7		
ES	TOTAL	3.0									
	PERSONS	3.2									
	GRAPHICS	3.0									
	PERSONS & GRAPHICS	2.5									

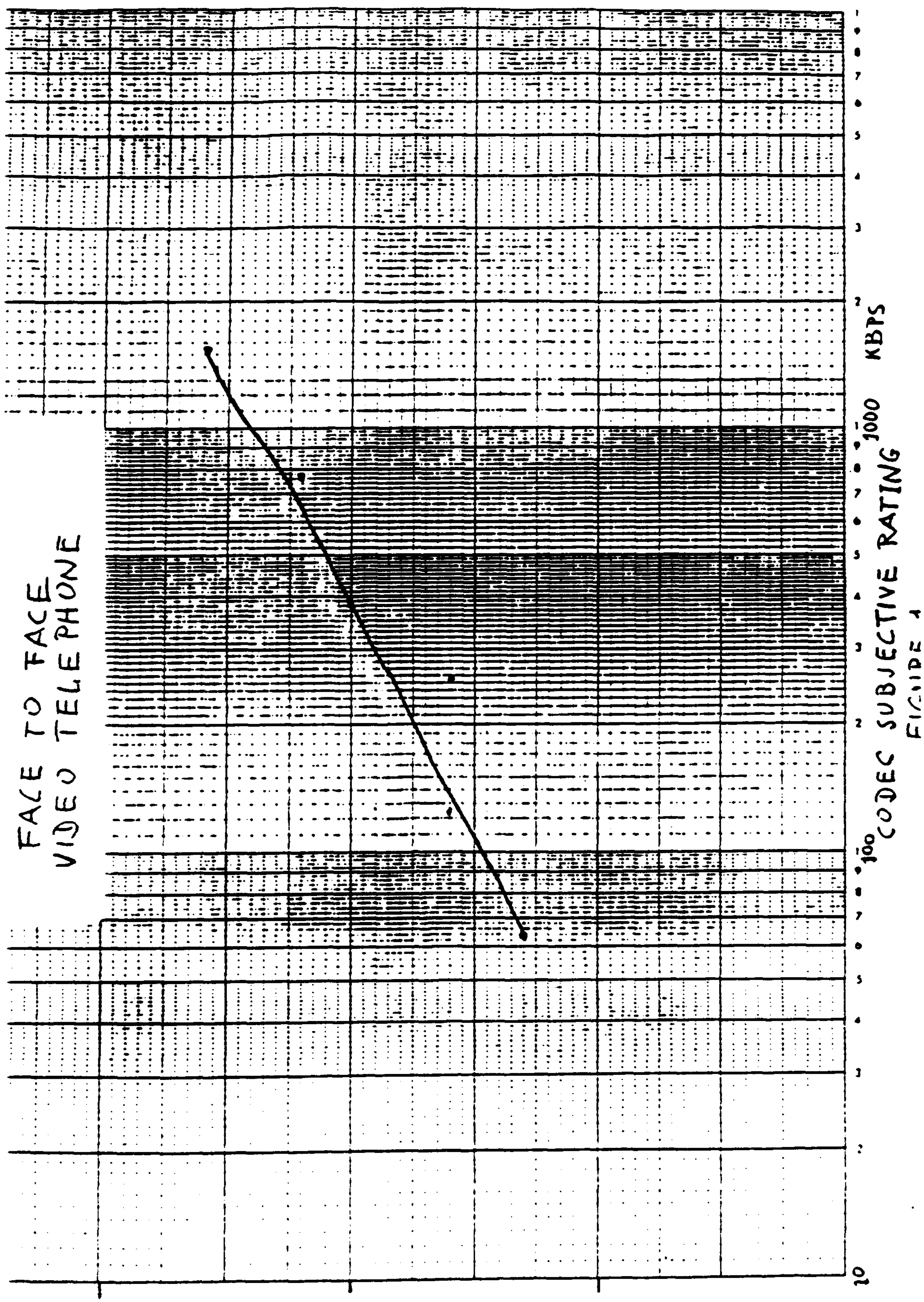
TABLE 5. TEST RESULTS - 384 KBPS

ATOR	SEGMENT	1		2		3			4		
	PART	1	2	1	2	1	2	3	1	2	AVERAGE
		-	2	3	3	2	4	4	3	1	2.8
		4	4	5	4	2.5	3	3.5	3	3.5	3.6
		4	3	4	4	2	4	4	3	2	3.3
		4	4	4	3	3	4	3	4	3	3.6
		3	3	3	3	2	3	3	3	2	2.8
		4	2	3	3	3	4	3	4	1	3.0
		3	2	4	3	3	4	3	4	3	3.2
		4	2	3	2	2	4	3	3	2	2.8
		4	4	4	4	3	4	4	4	3	3.8
		4	3	4	3	2	4	3	3	1	3.0
		4	3	3	4	3	4	3	3	1	3.1
		3	2	3	3	2	3	3	2	3	2.7
		4	3	3	3	2	4	3	3	1	2.9
		3	2	3	3	2	3	3	3	3	2.8
		3	3	3	2	2	3	2	3	2	2.6
	PART	3.6	2.8	3.5	3.1	2.4	3.7	3.2	3.2	2.1	
	SEGMENT	3.2		3.3		3.1			2.7		
ES	TOTAL	3.1									
	PERSONS	3.5									
	GRAPHICS	3.1									
	PERSONS & GRAPHICS	2.3									

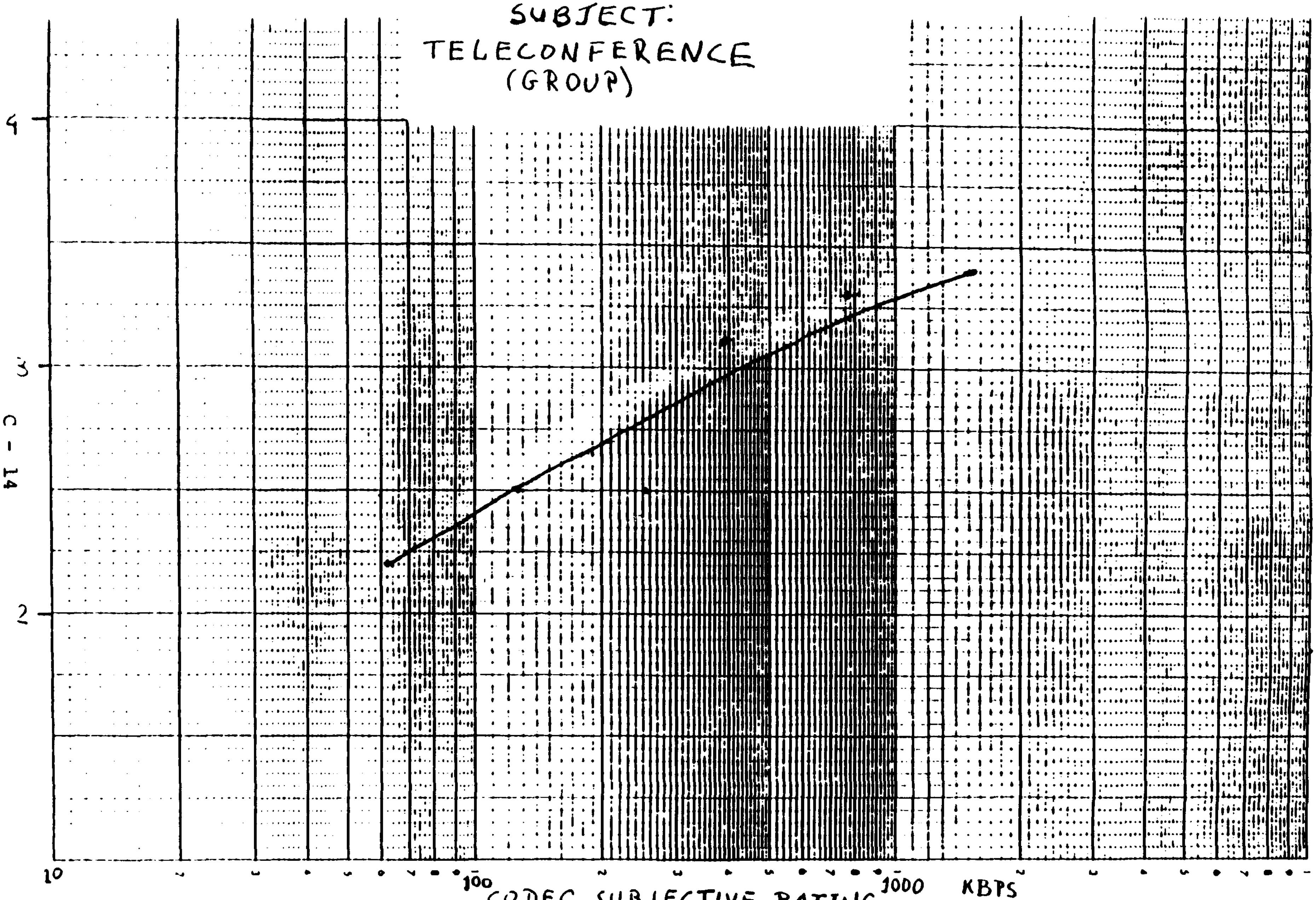
TABLE 6. TEST RESULTS -768 KBPS

JATOR).	SEGMENT	1		2		3			4		
	PART	1	2	1	2	1	2	3	1	2	AVERAGE
		2	2	2	2	2	3	3	3	2	2.3
		4	4	5	5	5	5	5	5	4	4.7
		5	5	5	4	5	5	5	5	4	4.8
		4	4	3	3	2	4	3	4	3	3.3
		4	4	3	3	4	4	4	4	3	3.7
		4	4	4	3	3	4	4	3	3	3.6
		4	3	4	3	3	4	4	4	3	3.6
		4	4	2	1	3	3	4	3	2	2.9
		4	3	4	4	4	4	4	4	4	3.9
		4	3	3	3	2	4	4	3	1	3.0
		4	3	3	4	3	4	4	4	2	3.4
		4	3	4	4	3	4	4	3	3	3.6
		4	3	4	3	3	4	4	4	1	3.3
		4	3	4	4	3	4	4	4	3	3.7
		4	3	3	3	2	3	3	3	2	2.9
	PART	3.9	3.4	3.5	3.3	3.1	3.9	3.9	3.7	2.7	
	SEGMENT	3.6		3.4		3.6			3.2		
GES	TOTAL	3.5									
	PERSONS	3.6									
	GRAPHICS	3.7									
	PERSONS & GRAPHICS	2.9									

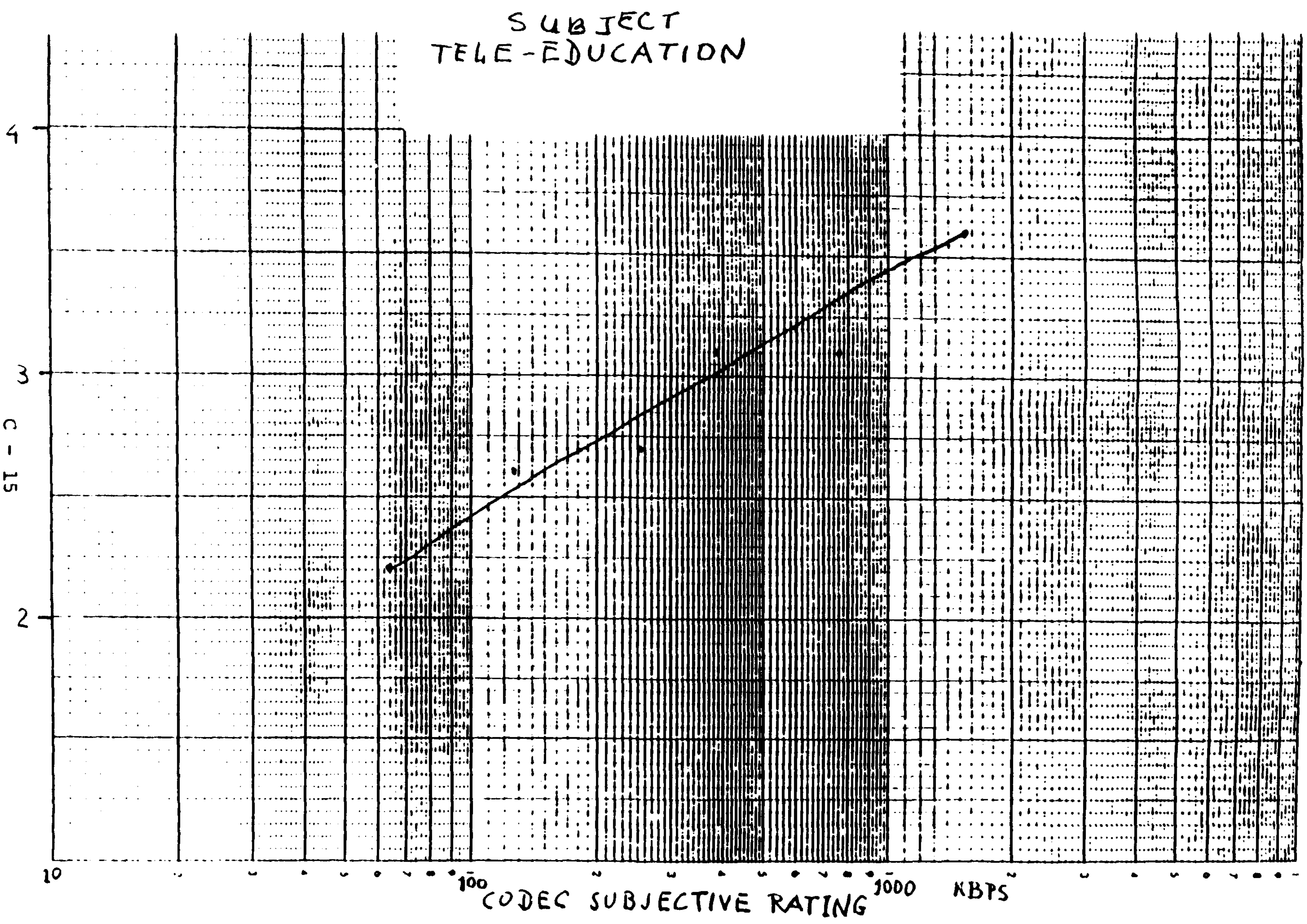
TABLE 7. TEST RESULTS - 1544 KBPS



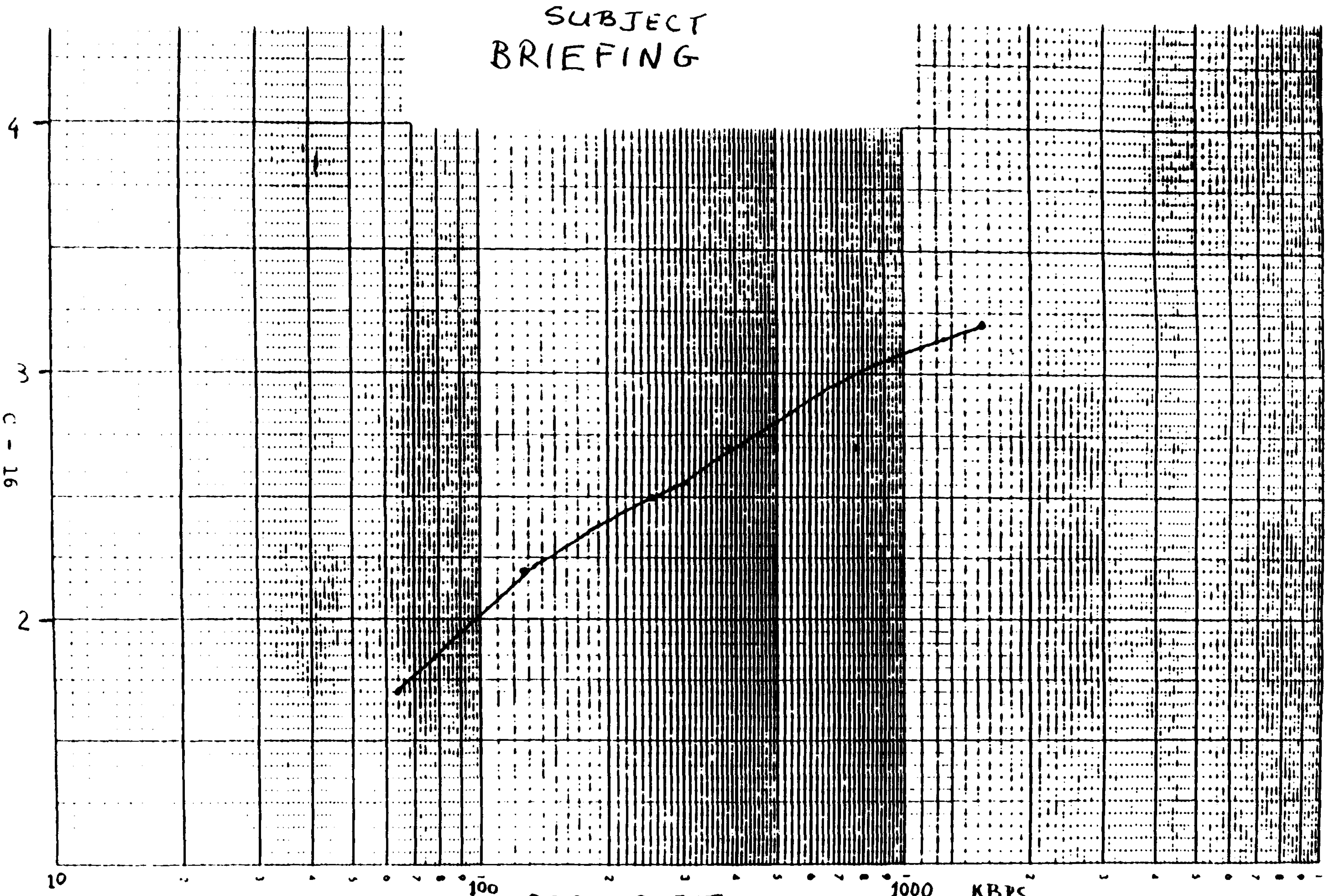
FACE TO FACE
VIDEO TELEPHONE
CODEC SUBJECTIVE RATING
FIGURE 4
KBPS
10
100
1000
4
3
2



CODEC SUBJECTIVE RATING

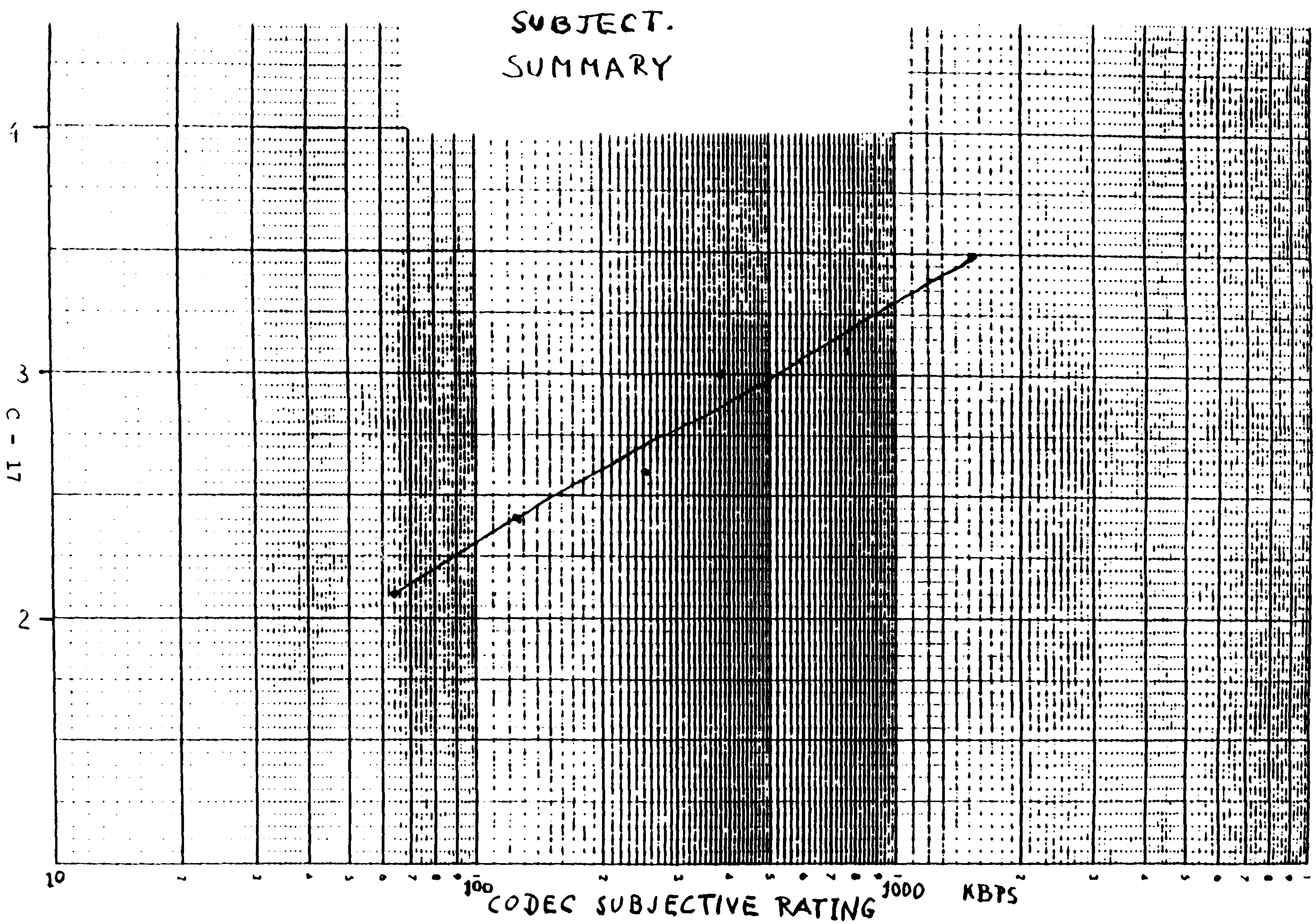


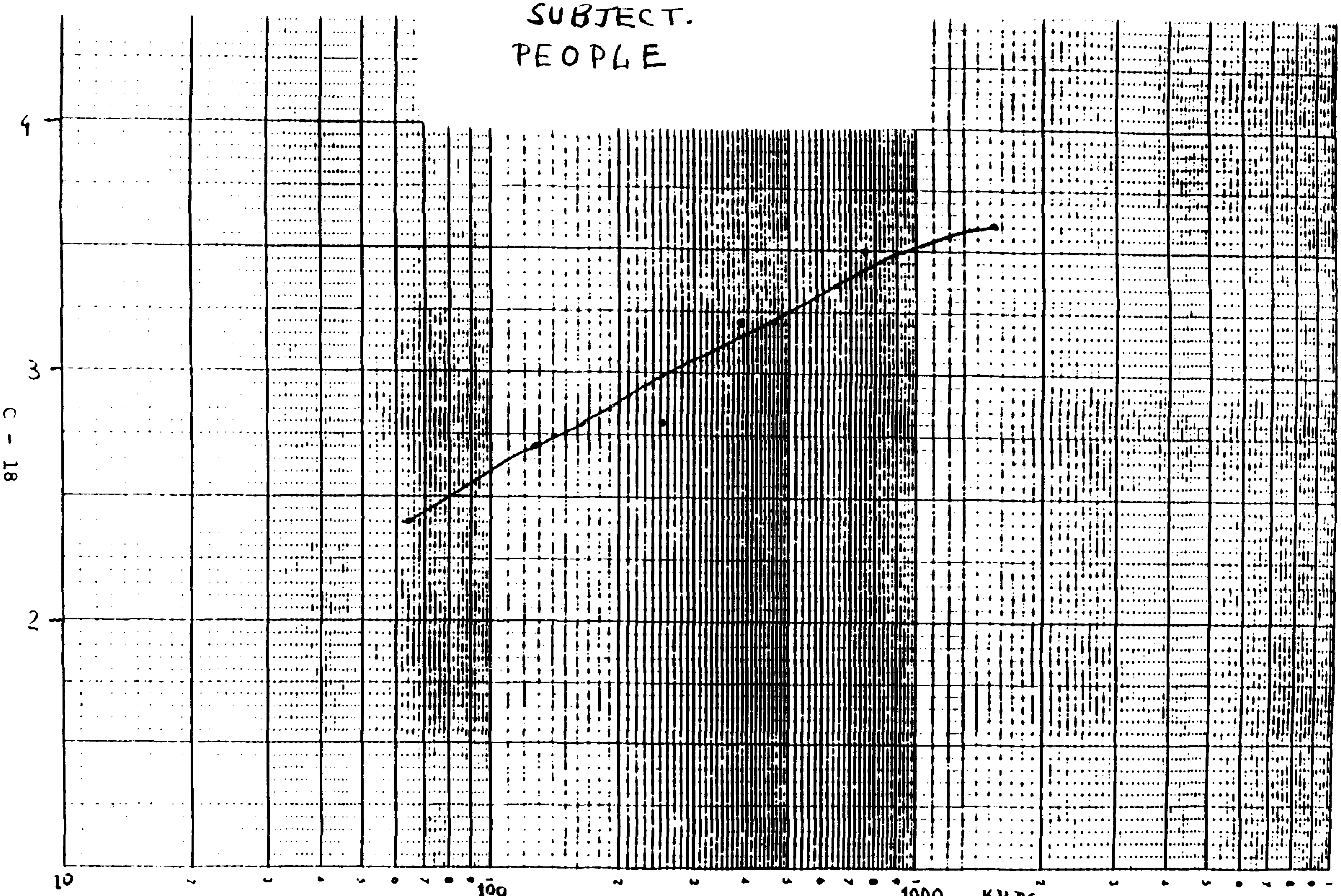
SUBJECT
TELE-EDUCATION
4
3
2
10
100
1000
CODEC SUBJECTIVE RATING
KBPS



CODEC SUBJECTIVE RATING

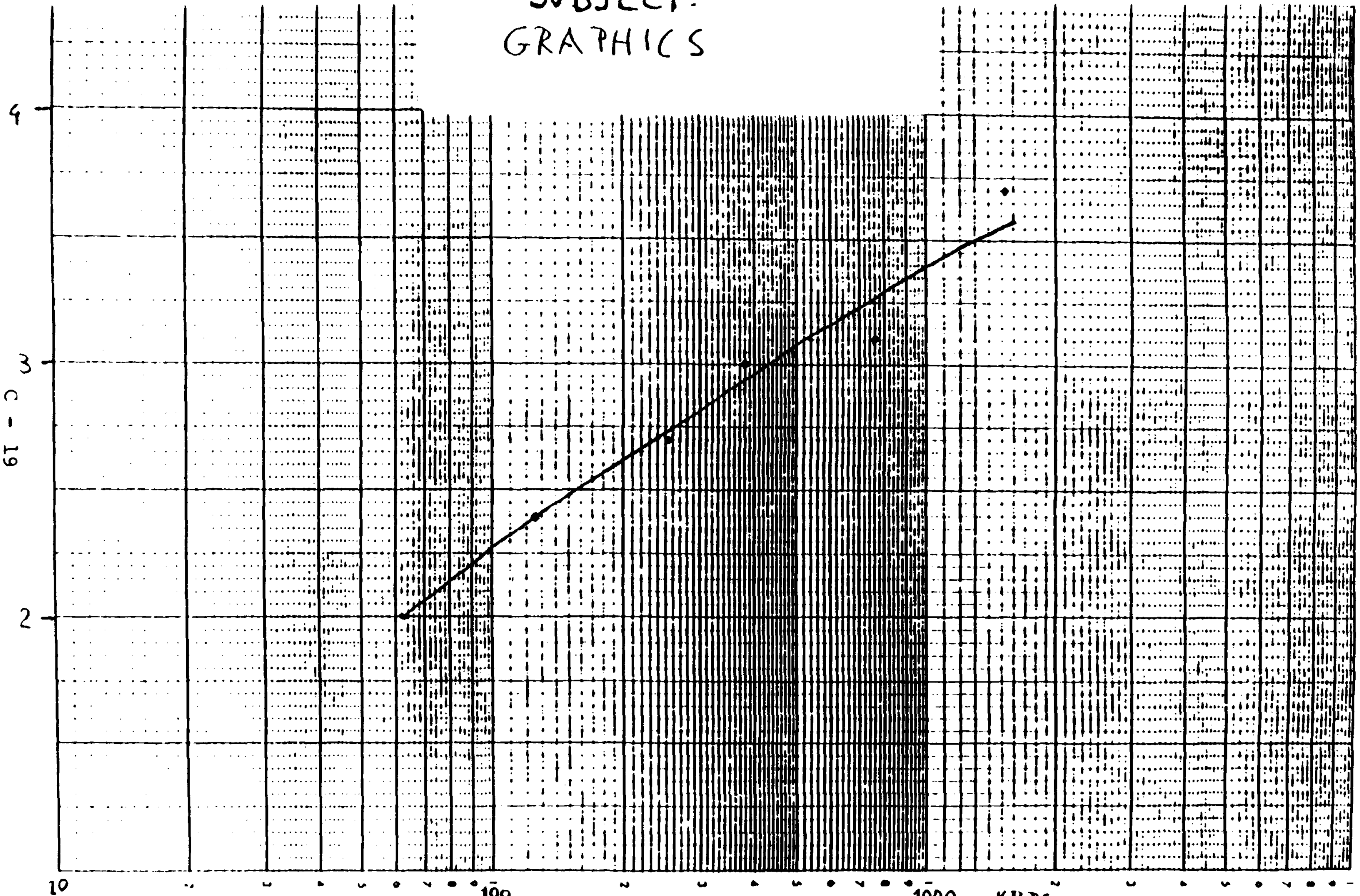
FIGURE 4


SUBJECT.
SUMMARY
4
3
2
10
100
1000
KBPS
CODEC SUBJECTIVE RATING

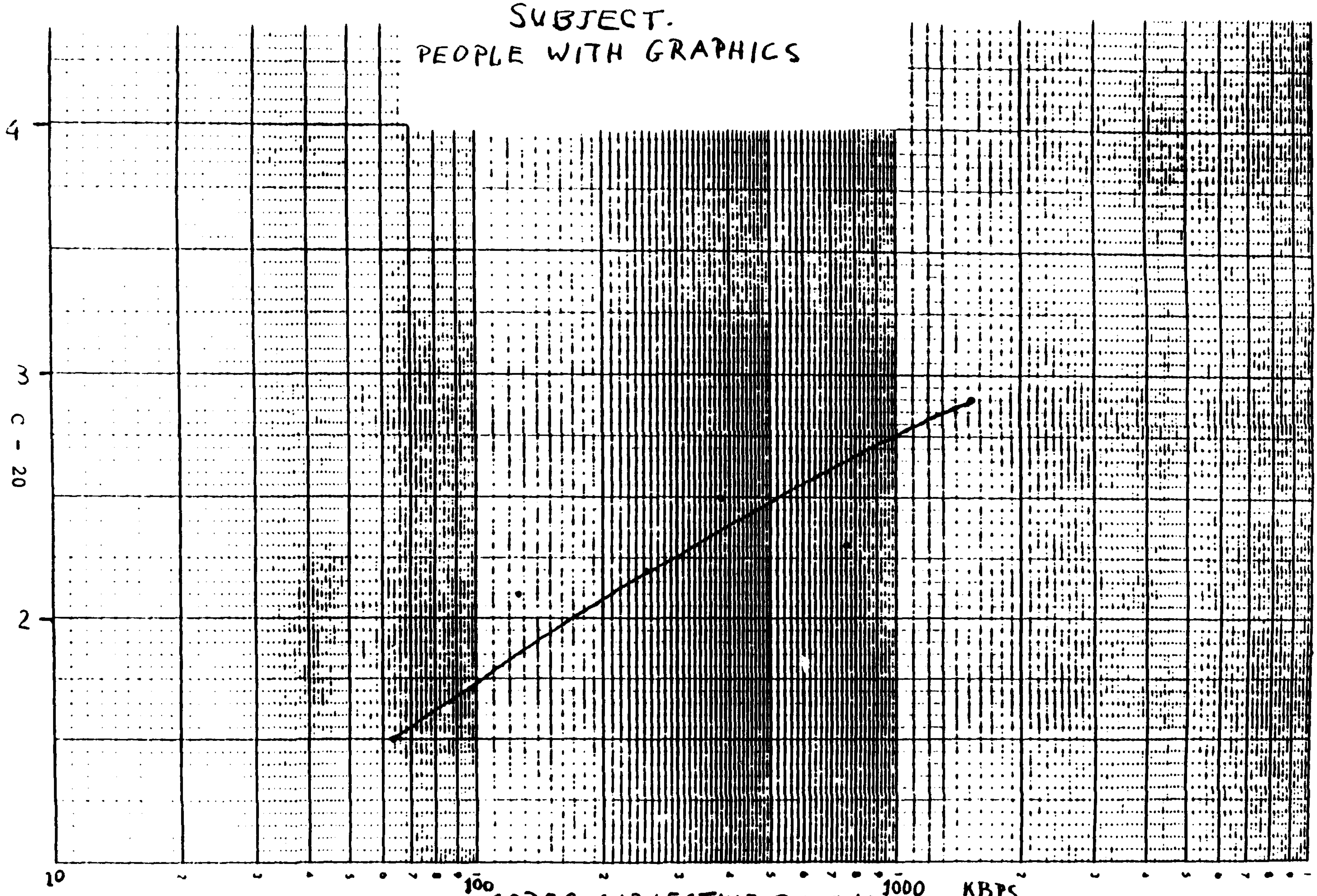


CODEC SUBJECTIVE RATING
FIGURE 6

SUBJECT.
GRAPHICS



CODEC SUBJECTIVE RATING
FIGURE 7



CODEC SUBJECTIVE RATING
FIGURE 0

APPENDIX D1

COMMITTEE T1
CONTRIBUTION

COMMITTEE T1
CONTRIBUTION

DOCUMENT NUMBER: T1Q1.5/89-102

****

STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

****

TITLE: LEVELS OF SERVICE

****

ISSUE ADDRESSED: LEVELS OF SERVICE

****

SOURCE: DELTA INFORMATION SYSTEMS, INC.
HORSHAM BUSINESS CENTER,
300 WELSH ROAD, BLDG. 3
HORSHAM, PENNSYLVANIA 19044
USA

****

DATE: 02-07-88

****

DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

****

KEYWORDS: Video, Teleconferencing,, Codecs

****

DISCLAIMER:

LEVELS OF SERVICE

The CCITT is developing a standard for video codecs operating at P x 64 Kbps where P can vary from 1 to 32 with particular emphasis at P = 1, 2, 6, 12, 24, 32. Two different formats have been adopted for this standard; Full CIF (Common Intermediate Format) and Quarter CIF.

	CIF	QCIF
Luminance Pels/line	360	180
Luminance Lines/picture	288	144
Chroma Pels/line	180	90
Chroma Lines/picture	144	72

The T1Y1.1 organization has also developed draft standards adopting these two picture points.

It is generally understood that one of the primary applications for the CIF format will be "teleconferencing" service where it is necessary to resolve multiple persons in a conference room. Conversely it is understood that one of the primary applications for the QCIF format will be the "videophone" desk-to-desk, person-to-person, service where the typical picture is a head and shoulders image.

Recommendation

Since T1Q1.5 is now considering the preparation of specifications for three levels of service it is recommended that the lowest level of service be based upon the QCIF format and the highest level of service be based upon the CIF format.

APPENDIX D2

COMMITTEE T1
CONTRIBUTION

DOCUMENT NUMBER: T1Q1.5/89-109

STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

TITLE: LEVELS OF SERVICE

ISSUE ADDRESSED: LEVELS OF SERVICE

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DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

KEYWORDS: Video, Teleconferencing, Graphics, Codecs, Resolution, Motion

DISCLAIMER:

LEVELS OF SERVICE

The CCITT and T1Y1.1 standards organizations have adopted the full CIF and Quarter CIF (QCIF) as standards for future video services. This document examines the anticipated relation of these standards with potential levels of service which be defined and specified.

Commonly used and descriptive designations for digital video applications are "video phone" and "teleconferencing". Therefore, the subsequent discussions deal with videophone and teleconferencing as representative applications of digital video.

Video phone typically shows head and shoulders of a single person. Facial features will be readily recognizable without requiring high picture resolution. Teleconferencing always entails groups of people, typically but not limited to three to six persons who are free to move about a conference room as desired. Higher resolution is needed for good teleconferencing service.

Graphics of all types, ranging from hand drawn sketches to complex high detail color printing, are an important part of most exchanges of visual information. High resolution (e.g. full CIF) is essential to ensure adequate readability. If the picture is static the only motion requirement relates to the speed of presenting a totally new picture. However, the use of a pointer or marker pen and possibly other limited motion is often needed to supplement the graphic information. Faithful rendition of such motion is not essential but a limited motion capability is highly desirable for acceptable performance.

Trade-offs between picture quality and motion rendition are usually necessary to produce the most desirable and cost effective implementation for different levels of service. The following table shows an overview of services and their possible performance requirements.

SERVICE	PEOPLE		GRAPHICS	
	VIDEOPHONE	TELECONFERENCE	STILL	WITH POINTER
SPATIAL RESOLUTION REQUIREMENT	Low (QCIF)	High (CIF)	High (CIF)	High (CIF)
TEMPORAL RESOLUTION REQUIREMENT	Moderate	High	Very Low	Low

APPENDIX D3

COMMITTEE T1
CONTRIBUTION

DOCUMENT NUMBER: T1Q1.5/90-116

****

STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

****

TITLE: LEVELS OF SERVICE

****

ISSUE ADDRESSED: LEVELS OF SERVICE

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DISTRIBUTION TO: T1Q1.5

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KEYWORDS: VIDEO TELECONFERENCING, VIDEO TELEPHONY, DEFINITIONS, ARTIFACTS, APPLICATIONS, PERFORMANCE

****

The table below summarizes five potential levels of service for Digital Video Teleconferencing/Video Telephony Service.

Level of Service	Spatial Resolution	Temporal Resolution	Typical Terminal Location	Typical Subject Matter	Typical Bit Rate Kbps
1	QCIF	Moderate (Head motion)	Desk	Talking Head	64/128
2	CIF	Moderate (Pointer motion)	Desk	Graphics/ Pointer	64/128
3	CIF	High	Conf. Room	Group (Working Level)	384
4	CIF	Very High	Conf. Room	Group (Executive)	1,544
5	HDTV	Moderate/ Low	Desk	Graphics	1,544

APPENDIX E

COMMITTEE T1
CONTRIBUTION

Document Number: T1Q1.5/88-082

****

STANDARDS PROJECT: Analog Interface Performance Specifications for Digital Video Teleconferencing/Video Telephony Service

****

TITLE: PICTURE ARTIFACTS WHICH MAY APPEAR IN VIDEO TELECONFERENCING SYSTEMS.

****

ISSUE ADDRESSED CODEC ARTIFACTS.

****

SOURCE: DELTA INFORMATION SYSTEMS, BY RICHARD SCHAPHORST.

****

DATE 11-8-88

****

DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/ VIDEO TELEPHONY.

****

KEYWORDS: Video, Teleconferencing, Telephony, Artifacts.

****

DISCLAIMER:

Title: Picture Artifacts which may appear in Video Teleconferencing Systems

Slope Overload

This type of noise appears mainly in predictive coding schemes. It is generated when the prediction error signal increases and exceeds the greatest representative value of the quantizing characteristics. It depends on this maximum value and the prediction method used, and causes a blurring of contours or a loss of resolution. Its shape, in particular, depends on the prediction function. Blocking can occur in systems employing block coding.

Edge Busyness

Edge busyness appears as jitter in the scanning direction in areas where the prediction error signal is large, such as sloping areas in the previous picture element prediction. This is due to non-linear quantization noise, and especially to the effect of the combination of slope overload and sampling points are locked and each frame is identical. As in slope overload, the direction of the jitter and its appearance depend on the prediction function used.

In the case of interframe or interfield coding, there are degradation of motion characteristics and specific degenerations peculiar to this type of 3-dimensional processing. Typical examples are "dirty window", "jerkiness" and "mosquito noise".

o Dirty window

This type of distortion occurs when the conditional picture element replenishment is used in coding based on interframe correlations. When threshold values are made too high to control the effective number of picture elements across the input video, part of the noise in the picture remains, so it seems as though one is looking into a room through a dirty window. Further, if significant/insignificant judgments are made over a block or a small area, it appears as if part of the picture is left stuck on. This degradation has a very strange effect.

o Mosquito Noise

This noise occurs as a characteristic of hybrid coding (for instance, when transform coding is combined with conditional picture element replenishment between frames). It occurs when both a moving object and background are in one block. The quantizing noise generated by the moving object also appears in the background, due to block processing. On the screen, it looks as though a mosquito is flying around a person's head and shoulders -- hence, the name.

Aliasing noise and interpolation noise

When the sampling frequency is less than twice the signal bandwidth, the sideband generated by sampling is superimposed on the spectrum of the original signal, and appears as noise. This is known as aliasing noise. Interpolation refers to a similar type of noise produced when the interpolation filter bandwidth is more than twice the sampling frequency, or the attenuation is insufficient.

Quantizing noise

The error produced with the original signal during quantization is known as quantizing noise. It may be divided into several types: the granular noise seen in areas where there is not much signal level variation when the number of quantizing bits is insufficient; the false contour observed in contour lines; and edge busyness, wherein the position of the edge appears to be moving when there is a rapid signal change.

APPENDIX F1

May 17, 1988

T1Q1.5

Technical Contribution

Subject: The Development of Objective Measures to Predict the Subjective Performance of Video Codecs

A subjective performance measure is required for video codecs in order to compare codecs and to optimize their design.

The process of developing subjective performance measures can be divided into the following steps:

1. Develop Subjective Tapes

These tapes should contain scenes that are typical for the specific application. Some of the applications could be broadcasting, group teleconferencing, videphone, and teletraining.

2. Develop Objective Measures

The measures must encompass all aspects of the signal: spatial, intensity, time, color resolution, noise levels, linearity, etc. While the measures should be technology independent, some knowledge of the technology that could be used is essential to the development of efficient measures. Most of the measurements can be made with the aid of known signals, on tape, and a device that compares the output of the codec with the known input.

3. Obtain Subjective and Objective Measurements

Subjective and objective measurements should be made on a wide variety of codecs, or other devices that distort the video signal Subjective measurements are made by inputting the subjective tapes and evaluating the output by a jury. The jury might be a sample from the population that will eventually use the device. It is desirable to obtain the widest possible variations in objective performance, since it will be easier to interpolate subjective performance between test codecs than to extrapolate to performance regions that have not been measured.

4. Find Correlations Between Subjective and Objective Measures

Analysis of the above results can be used to generate a prediction formula that converts the objective measures into a more or less continuous prediction of the subjective performance. Perhaps multiple regression could be used. This would be repeated for each application. Bayes theorem does not appear to be appropriate because of the limited number of categories and the requirement to know the *a priori* values of each category. Another approach may be to write a computer program that accepts the objective measurements, the application, and any user biases, and generates the predicted subjective performance. This could perhaps be implemented by an expert system.

APPENDIX F2

A N N E X B

May 17, 1988

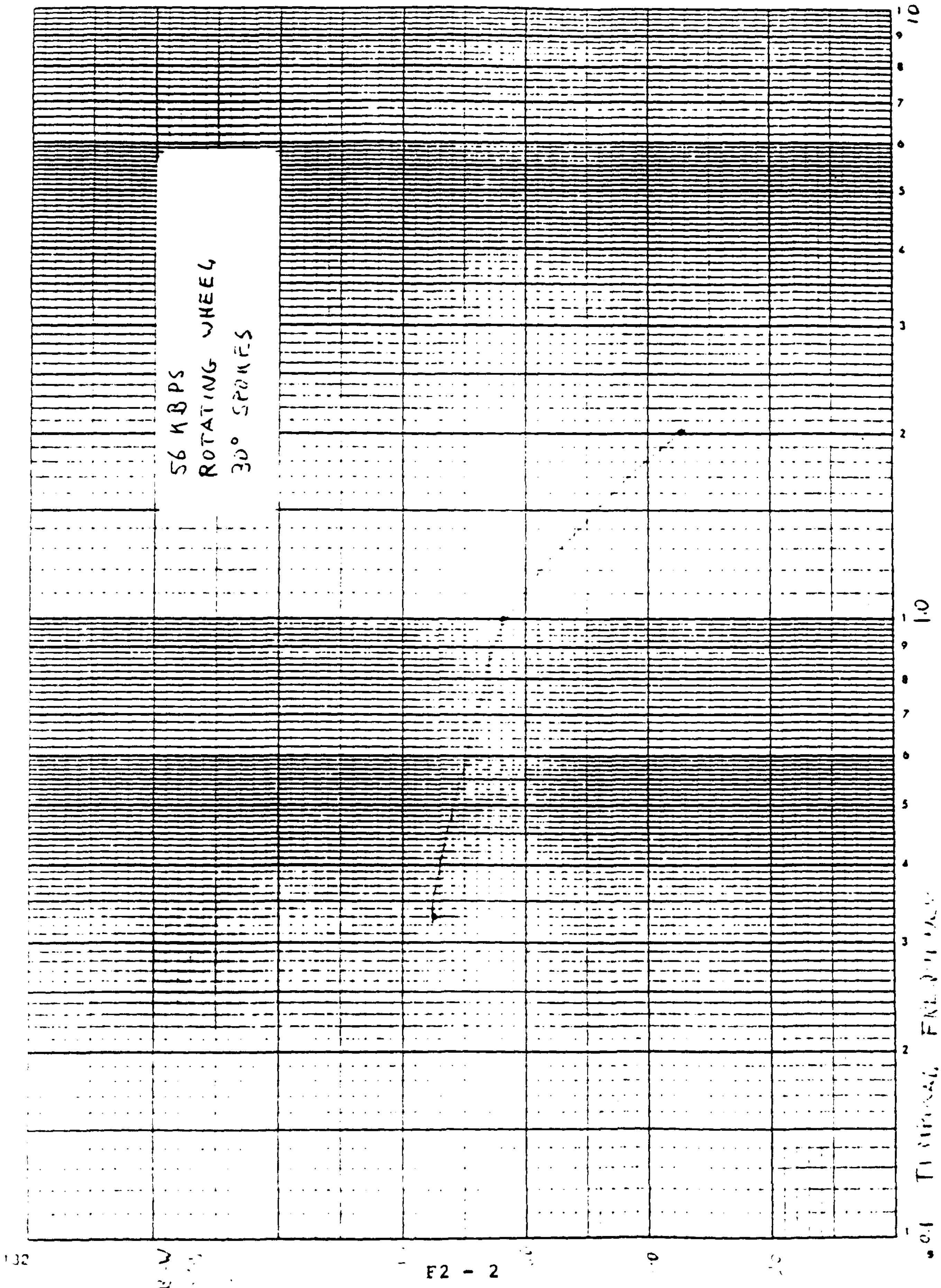
T1Q1.5
Technical Contribution

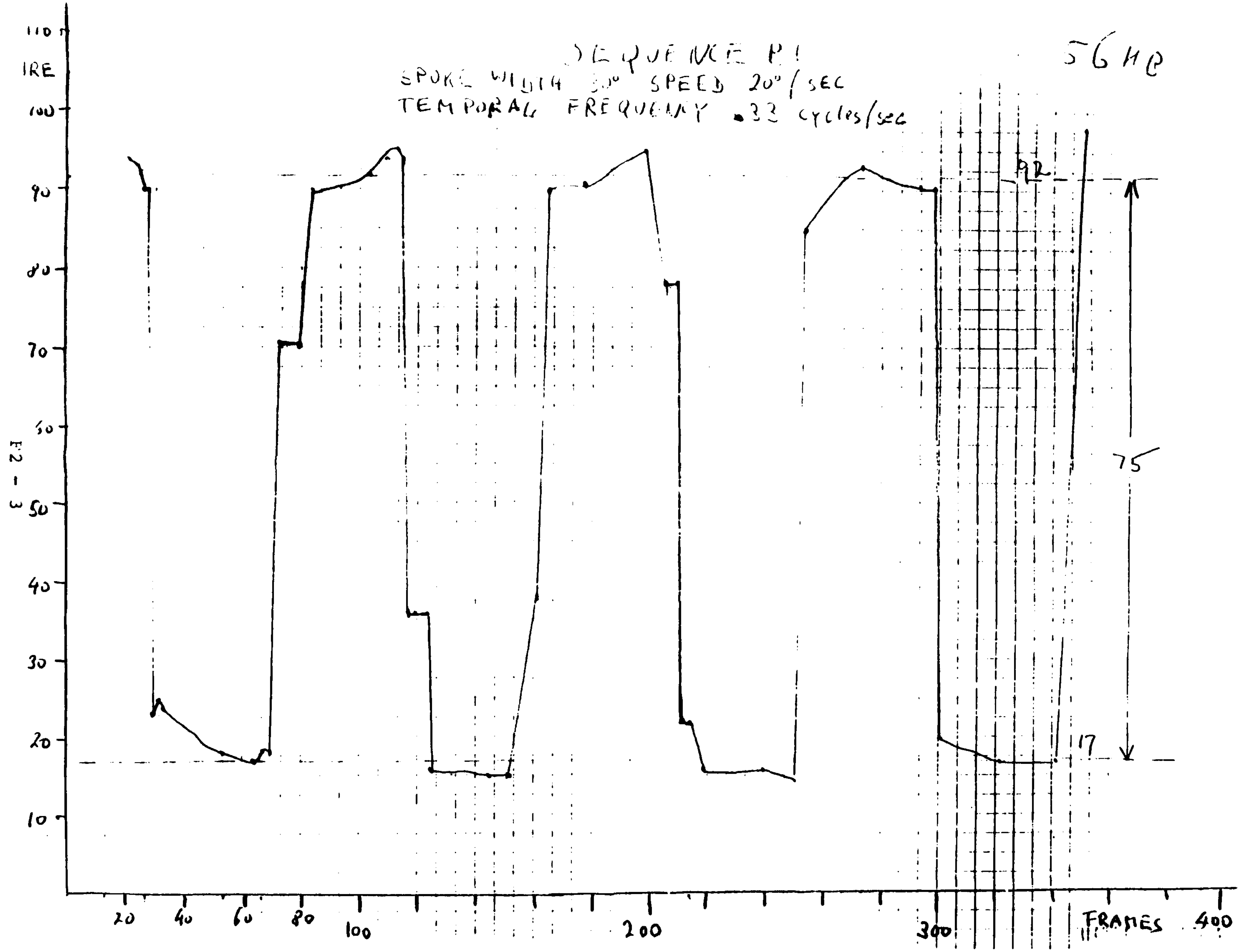
Subject: Status of Project to Measure Temporal Resolution (Frequency Response) of Teleconferencing Video Codecs

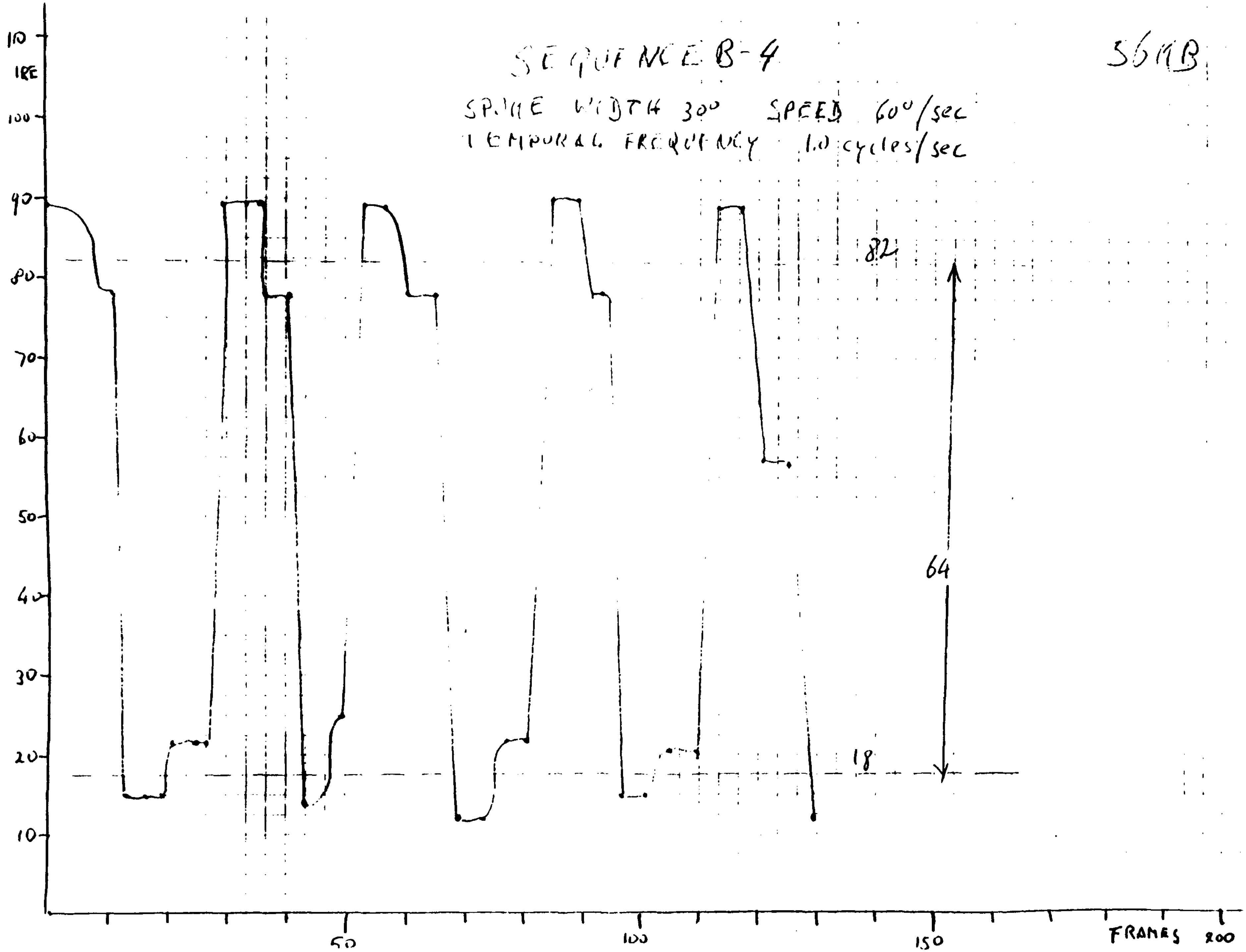
The test tape for the objective testing of motion performance of teleconferencing video codecs which was described in the contribution by Delta Information Systems dated March 2, 1988 has been processed through several codecs at bit rates ranging from 56 kbps to 1.544 Mbps. At present these processed tapes are being analyzed and preliminary partial results are available.

The test tape contains two different groups of test patterns. The A group consists of white dots of three sizes which are switched alternately with a black field at different rates. The B group contains black spokes of three width rotating over a combined white and colored background at different speeds. In both cases the amplitudes of the white to black transitions are measured on a selected line at a selected spot. The number of transitions per second are known for each pattern, therefore a temporal frequency can be used as horizontal axis for a temporal response curve which depicts the motion rendition capability of a video codec.

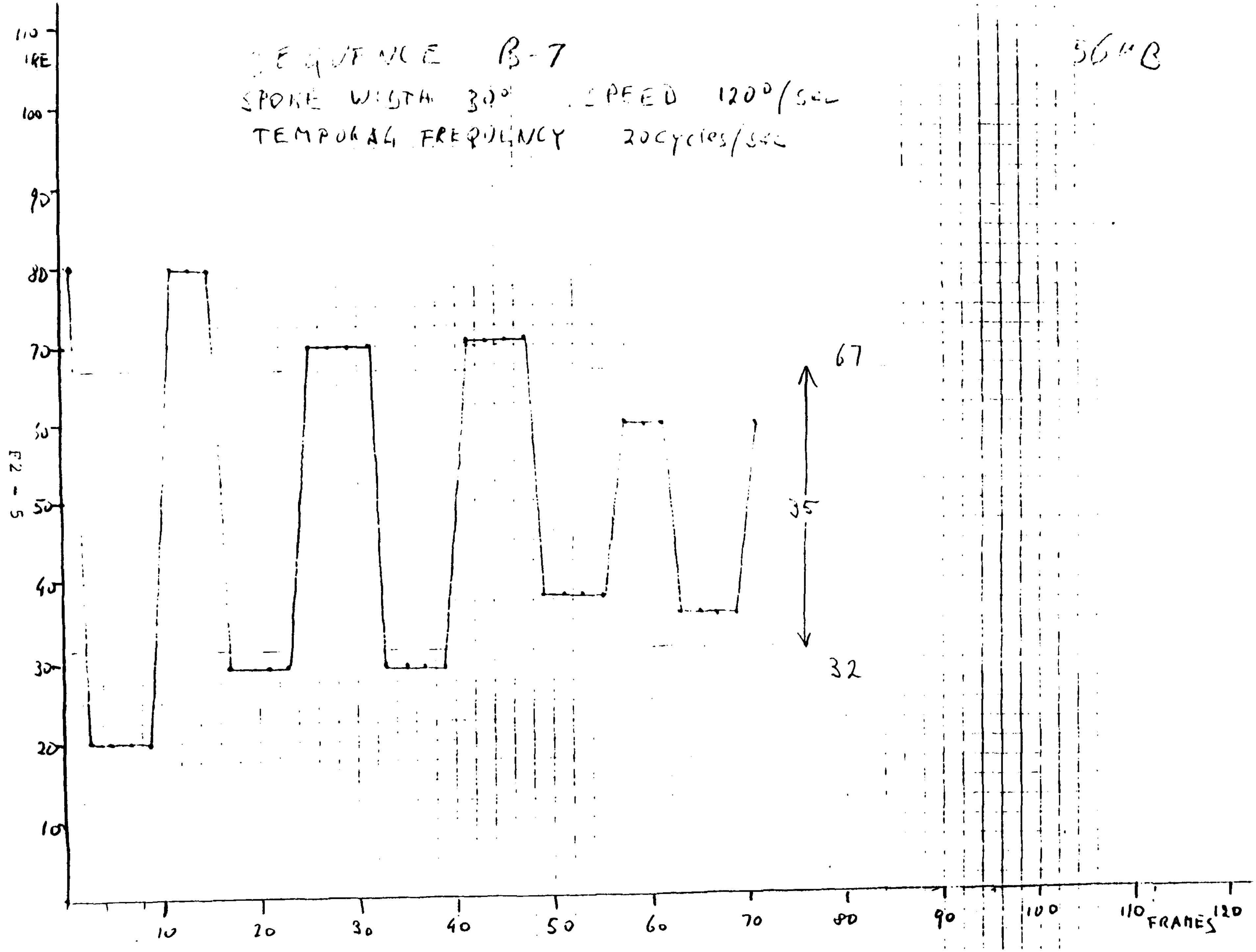
The attached diagrams show samples of resulting white and black amplitudes over a series of consecutive frames using various patterns, speeds (as produced by switching rate or rotation speed) and bit rates. The resulting estimated average amplitudes are used in the sample temporal response curves. Though these curves are based on a cursory preliminary analysis the dependence on temporal frequency and codec bit rate is clearly apparent.


56 KBPS
ROTATING WHEEL
30° SPOKES
10
1.0
0.1

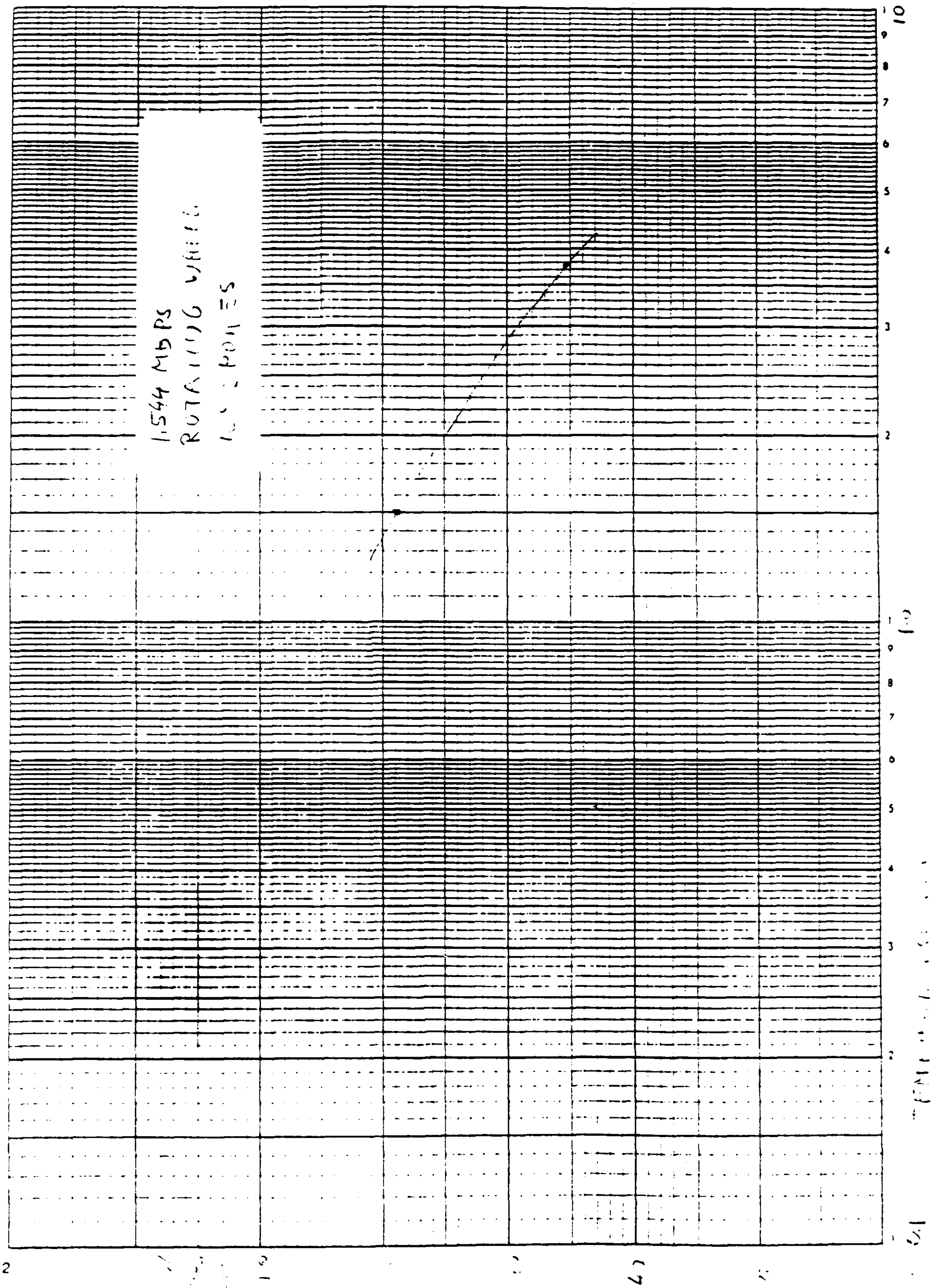

SEQUENCE P1
SPOKE WIDTH 30° SPEED 20°/SEC
TEMPORAL FREQUENCY .33 cycles/sec
56 HP
IRE
110
100
90
80
70
60
50
40
30
20
10
20
40
60
80
100
200
300
400
FRAMES
92
75
17

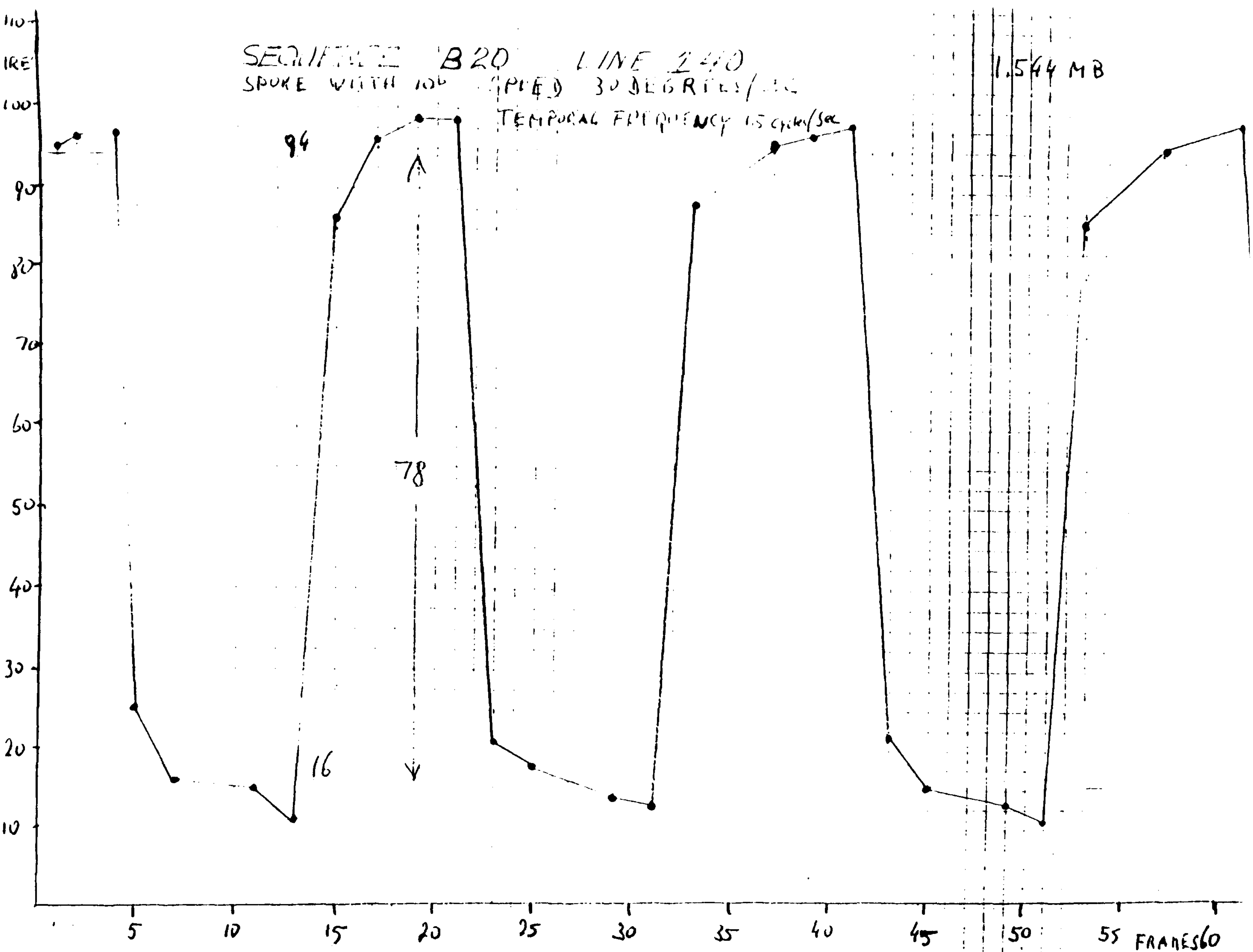


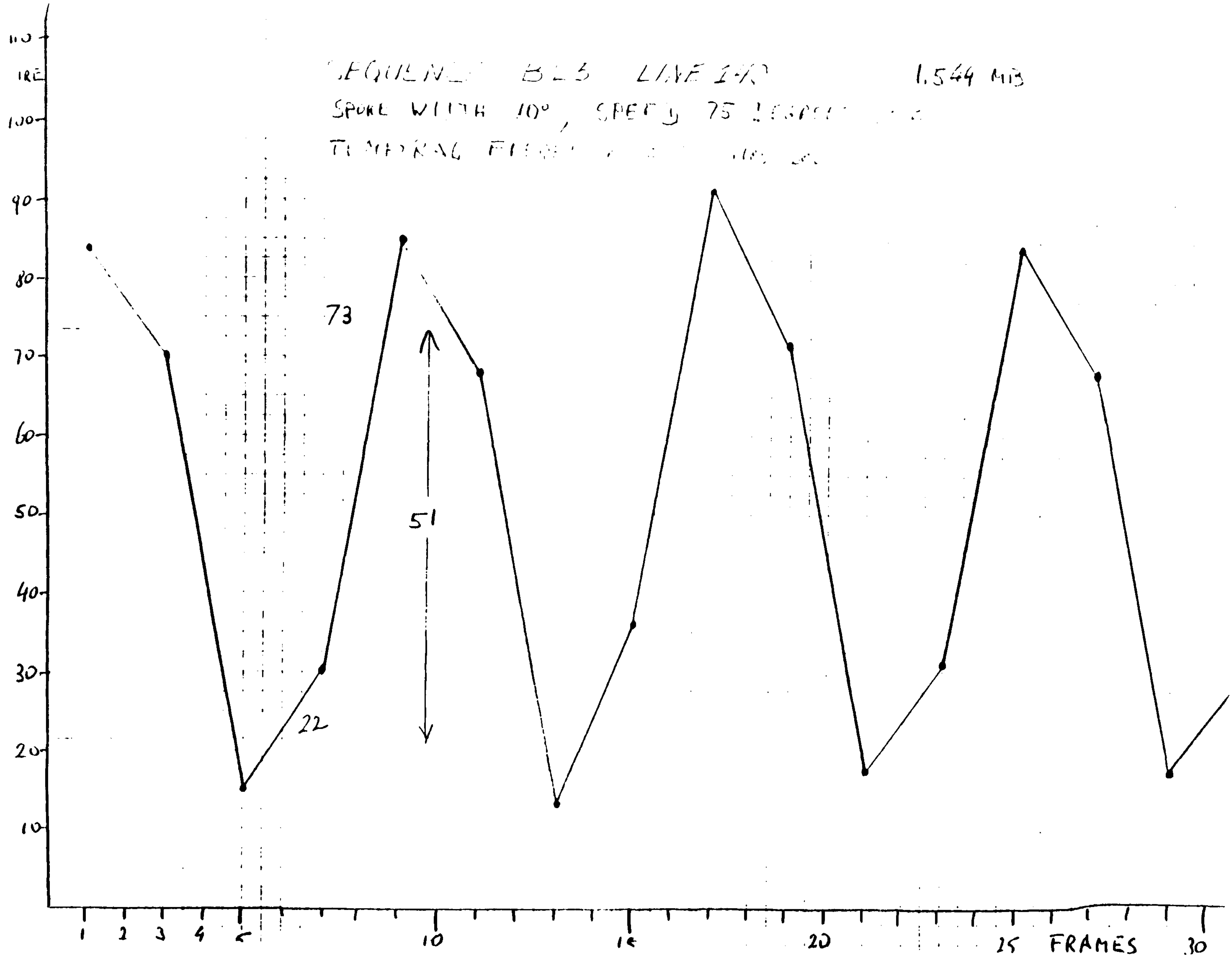
SEQUENCE B-4
56MB
SPINE WIDTH 30° SPEED 60°/sec
TEMPORAL FREQUENCY 1.0 cycles/sec
IRE
110
100
90
80
70
60
50
40
30
20
10
82
64
18
FRAMES
50
100
150
200


SEQUENCE B-7
SPOKE WIDTH 30° SPEED 120°/SEC
TEMPORAL FREQUENCY 20cycles/SEC
56"C
IRE
110
100
90
80
70
60
50
40
30
20
10
67
35
32
10
20
30
40
50
60
70
80
90
100
110
120
FRAMES

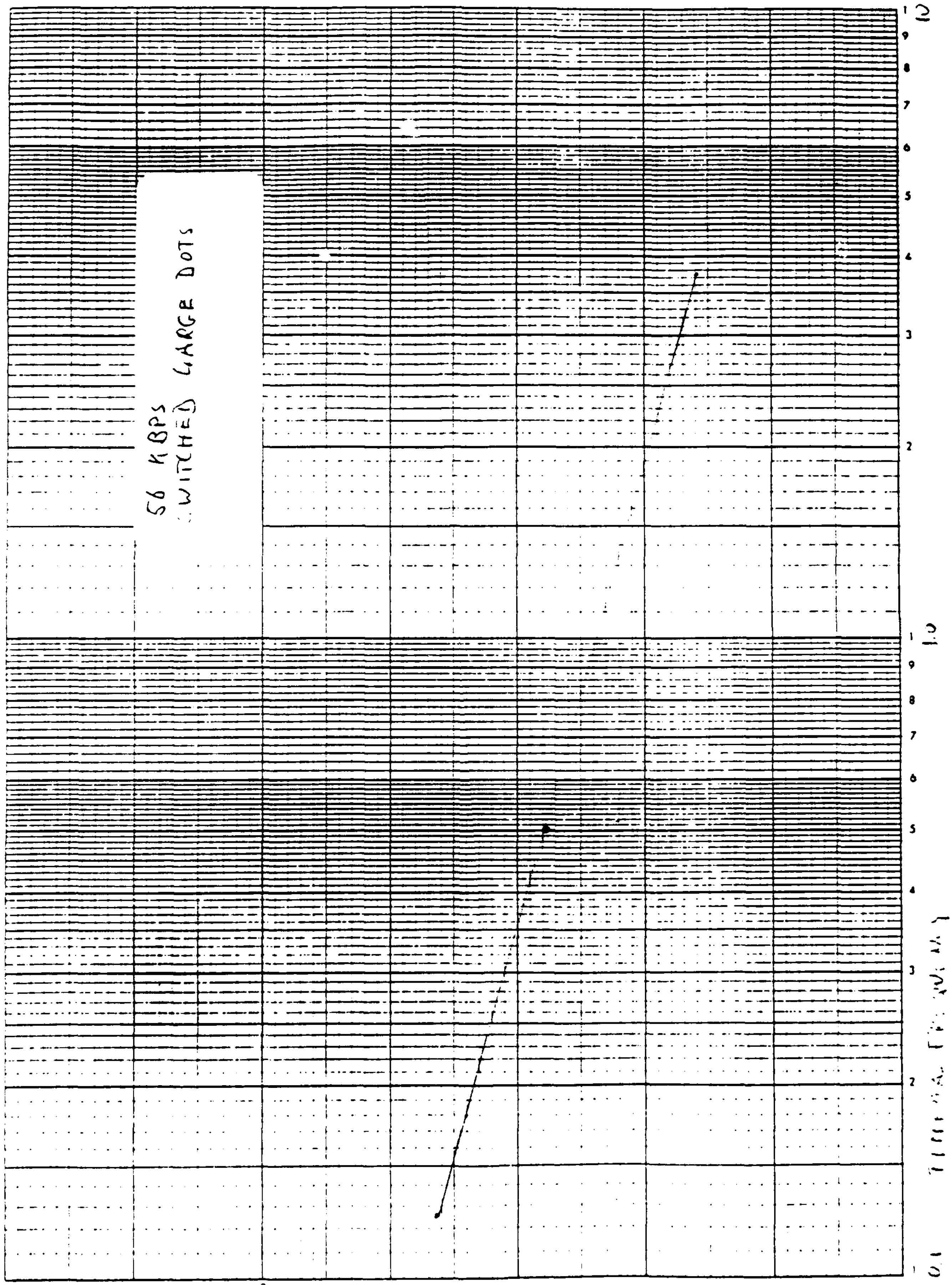
70 Divisions 5th, 10th Accent by 2 Cycle Semi-Log



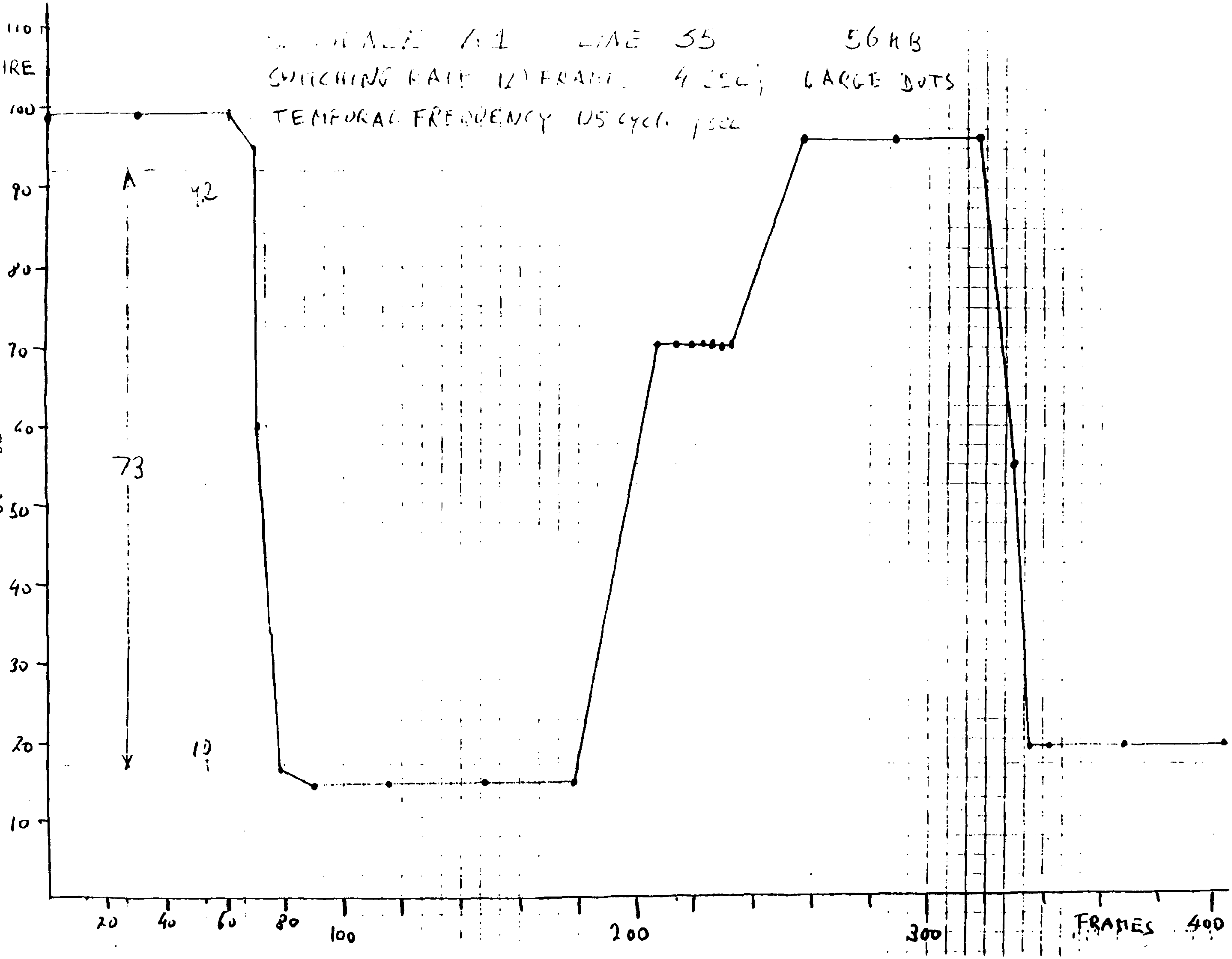

B20 LINE
SPOKE WITH
30 DEGREES/
TEMPORAL
1.544 MB
94
78
16
IRE
110
100
90
80
70
60
50
40
30
20
10
5
10
15
20
25
30
35
40
45
50
55
FRAMES 60


1.544 MB
SPOKE WIDTH 10°,
IRE
110
100
90
80
70
60
50
40
30
20
10
73
51
22
1
2
3
4
10
20
25
FRAMES
30

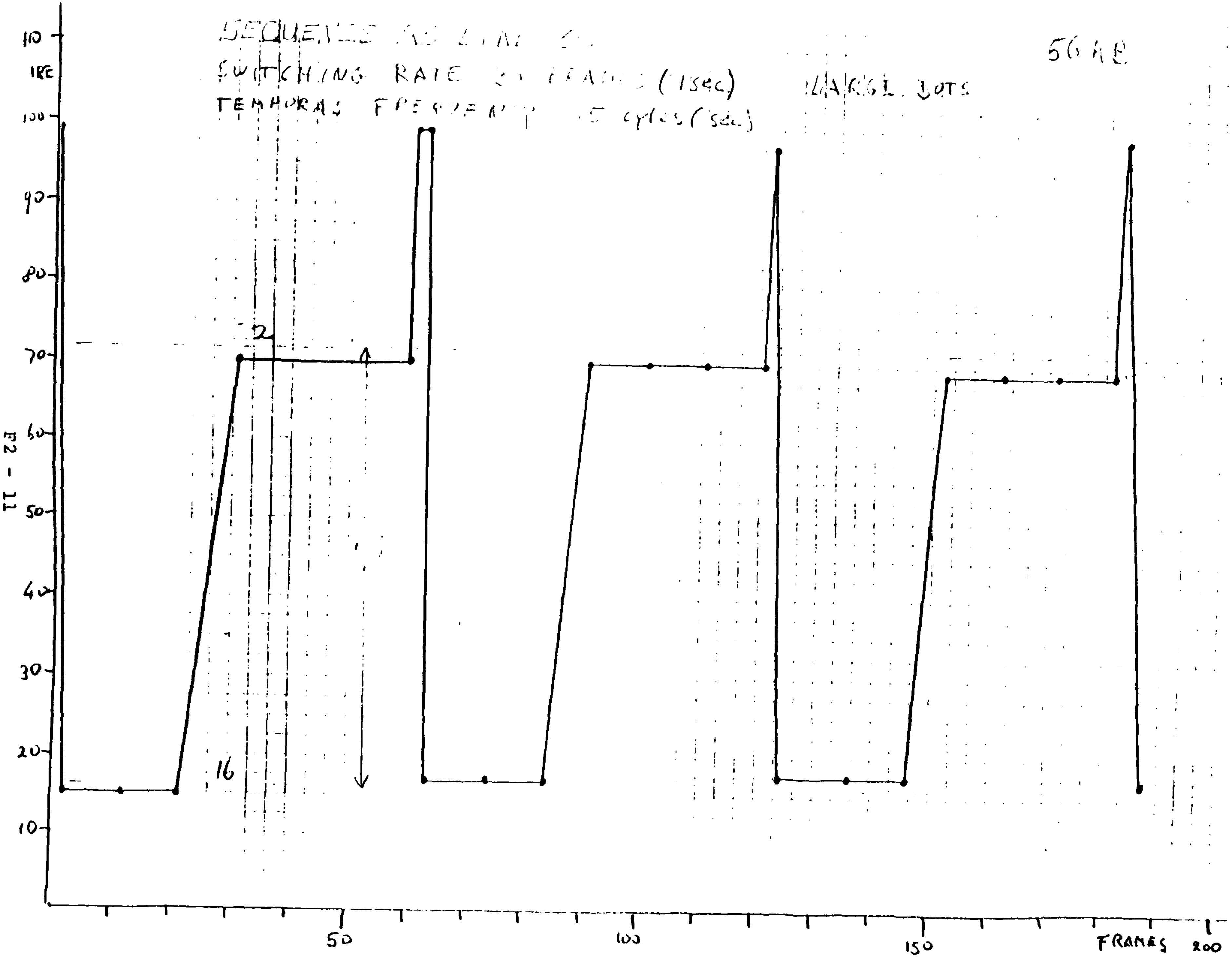
70 Divisions 5th, 10th Accent by 2 Cycle Semi-Log

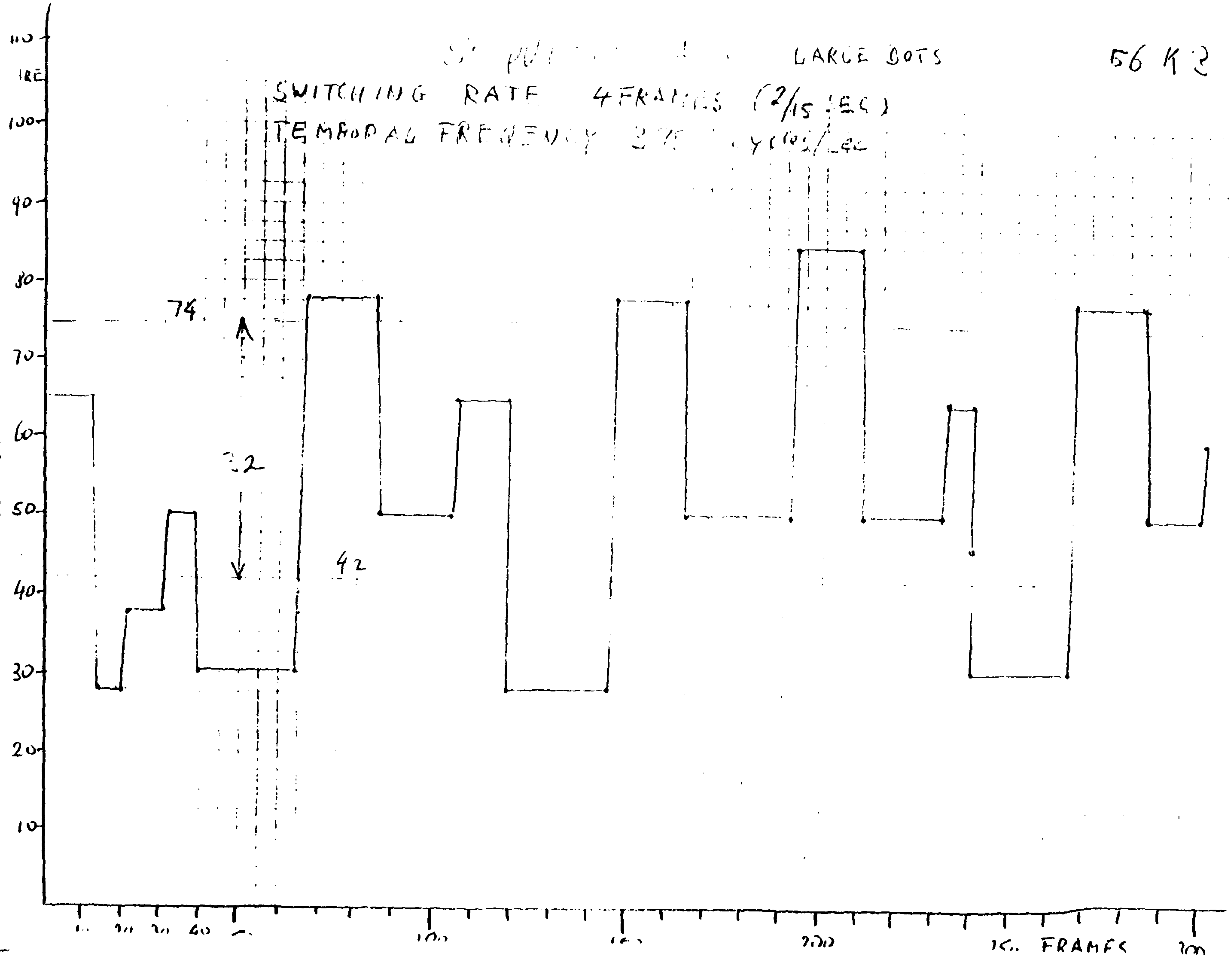


132



55
56 HB
LARGE DOTS
TEMPORAL FREQUENCY
IRE
110
100
90
80
70
60
50
40
30
20
10
73
42
FRAMES
20
40
60
80
100
200
300
400


SWITCHING RATE
(1sec)
TEMPORAL
cycles (sec)
IRE
10
100
90
80
70
60
50
40
30
20
10
2
16
50
100
150
FRAMES
200


LARGE DOTS
56 K 3
SWITCHING RATE 4 FRAMES (2/15 SEC)
TEMPORAL FREQUENCY
74.
32
42
IRE
110
100
90
80
70
60
50
40
30
20
10
FRAMES
200

A N N E X C

May 17, 1988

White Paper

Subject: The Development of Objective Measures to Predict the Subjective Performance of Video Codecs

A subjective performance measure is required for video codecs in order to compare codecs and to optimize their design.

The process of developing subjective performance measures can be divided into the following steps:

1. Develop Subjective Tapes

These tapes should contain scenes that are typical for the specific application. Some of the applications could be broadcasting, group teleconferencing, videphone, and teletraining.

2. Develop Objective Measures

The measures must encompass all aspects of the signal: spatial, intensity, time, color resolution, noise levels, linearity, etc. While the measures should be technology independent, some knowledge of the technology that could be used is essential to the development of efficient measures. Most of the measurements can be made with the aid of known signals, on tape, and a device that compares the output of the codec with the known input.

3. Obtain Subjective and Objective Measurements

Subjective and objective measurements should be made on a wide variety of codecs, or other devices that distort the video signal. Subjective measurements are made by inputting the subjective tapes and evaluating the output by a jury. The jury might be a sample from the population that will eventually use the device. It is desirable to obtain the widest possible variations in objective performance, since it will be easier to interpolate subjective performance between test codecs than to extrapolate to performance regions that have not been measured.

4. Find Correlations Between Subjective and Objective Measures

Analysis of the above results can be used to generate a prediction formula that converts the objective measures into a more or less continuous prediction of the subjective performance. Perhaps multiple regression could be used. This would be repeated for each application. Bayes theorem does not appear to be appropriate because of the limited number of categories and the requirement to know the a priori values of each category. Another approach may be to write a computer program that accepts the objective measurements, the application, and any user biases, and generates the predicted subjective performance. This could perhaps be implemented by an expert system.

APPENDIX F3

T1Q1.5
Technical Contribution

Subject: Status of Project to Measure Temporal Resolution (Frequency Response) of Teleconferencing Video Codecs

The test tape for the objective testing of the motion performance of teleconferencing video codecs, which was described in a prior contribution by Delta Information Systems, has been processed through several codecs at bit rates ranging from 56 kbps to 1.544 Mbps. At present these processed tapes are being analyzed and preliminary partial results are available.

The test tape contains black spokes of three widths rotating over a combined white and colored background at different speeds (see Figure 1). The amplitudes of the white to black transitions are measured (see Figure 2) on a selected line at a selected spot. The number of transitions per second are known for each pattern; therefore a temporal frequency can be used as horizontal axis for a temporal response curve which depicts the motion rendition capability of a video codec.

Figures 3, 4, and 5 show samples of frequency response curves for various combinations of codec bit rate, spoke width, and rotation. Though these curves are based on a preliminary analysis the dependence on temporal frequency and codec bit rate is clearly apparent.

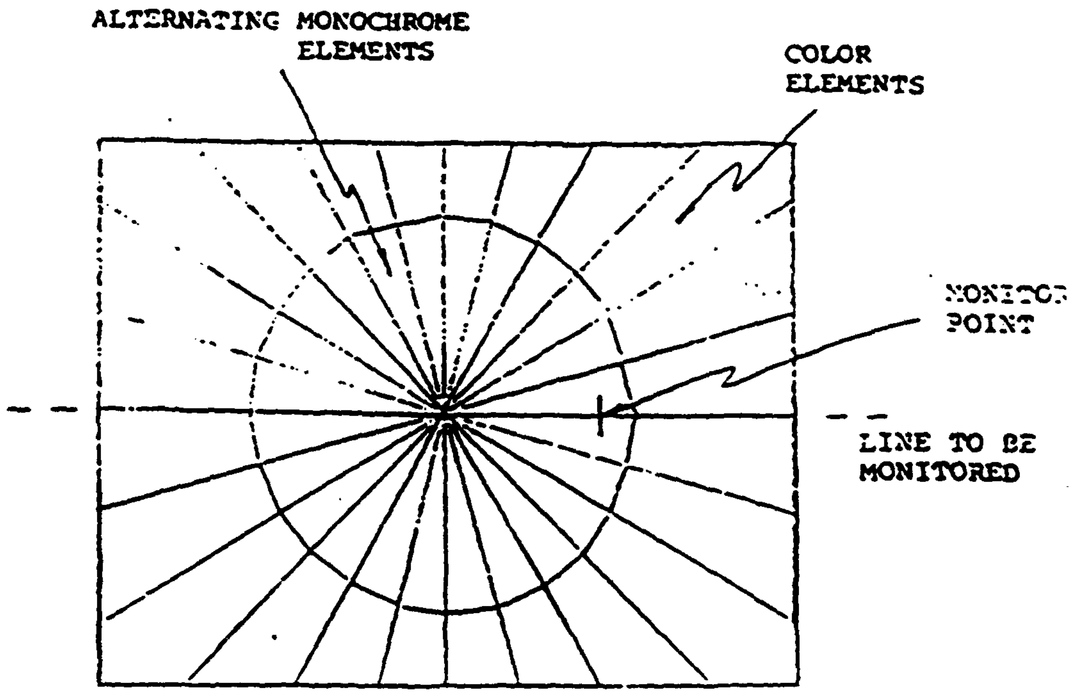


FIGURE 1 ROTATING WHEEL PATTERN

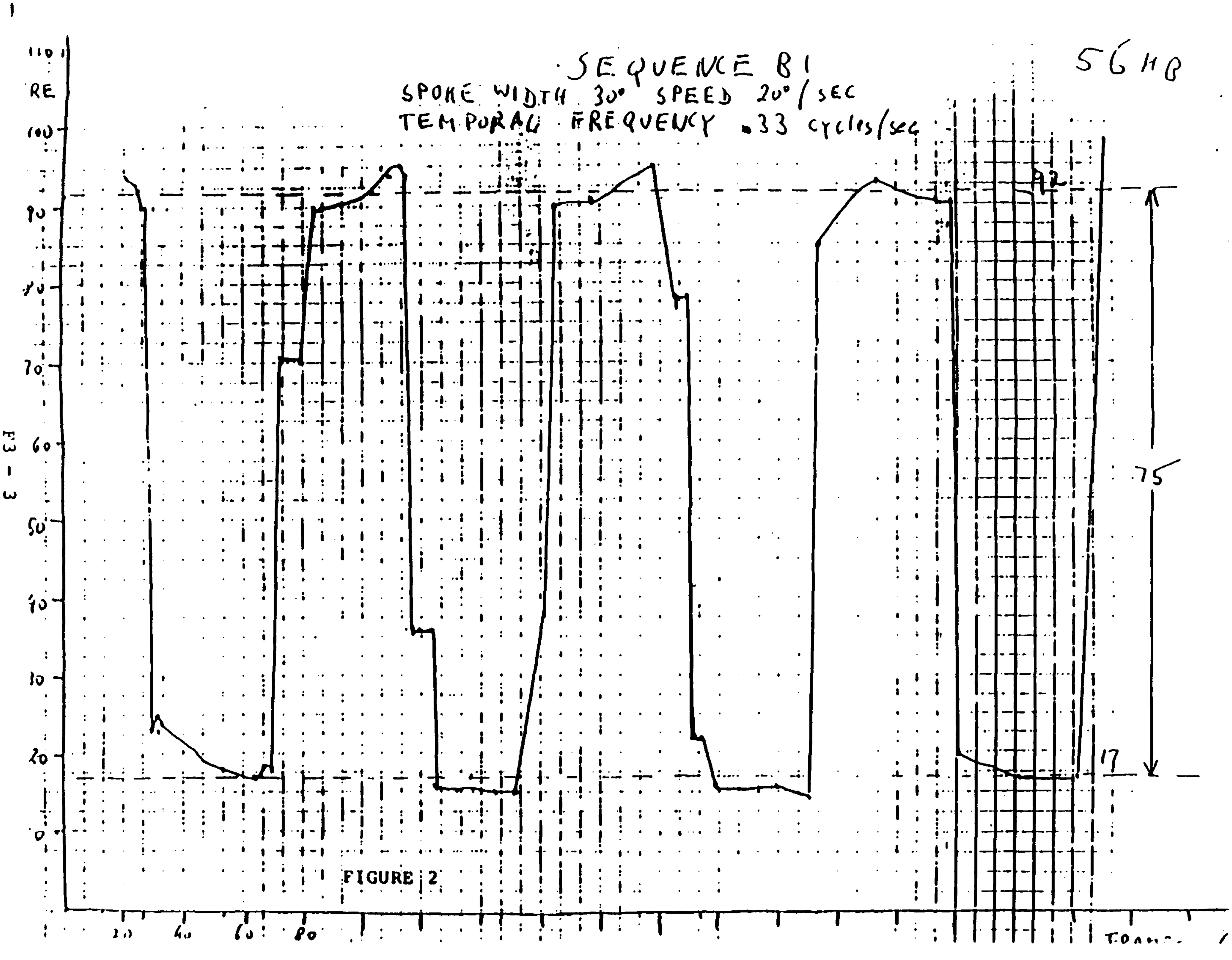
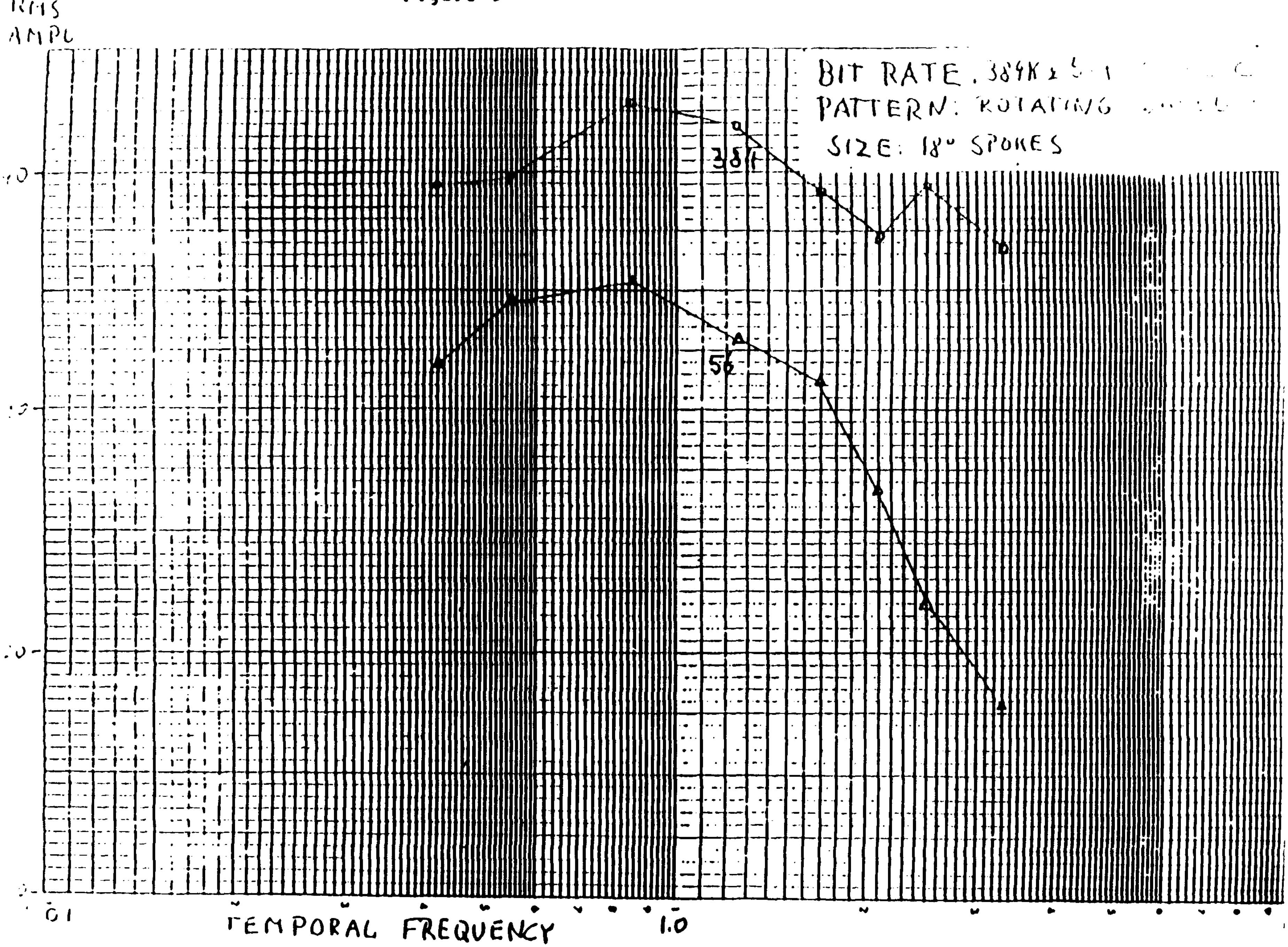

SEQUENCE B1
SPOKE WIDTH 30° SPEED 20°/SEC
TEMPORAL FREQUENCY .33 cycles/sec
56 HB
RE
75
17
92
110
100
90
70
60
50
40
30
20
0
40
60
80

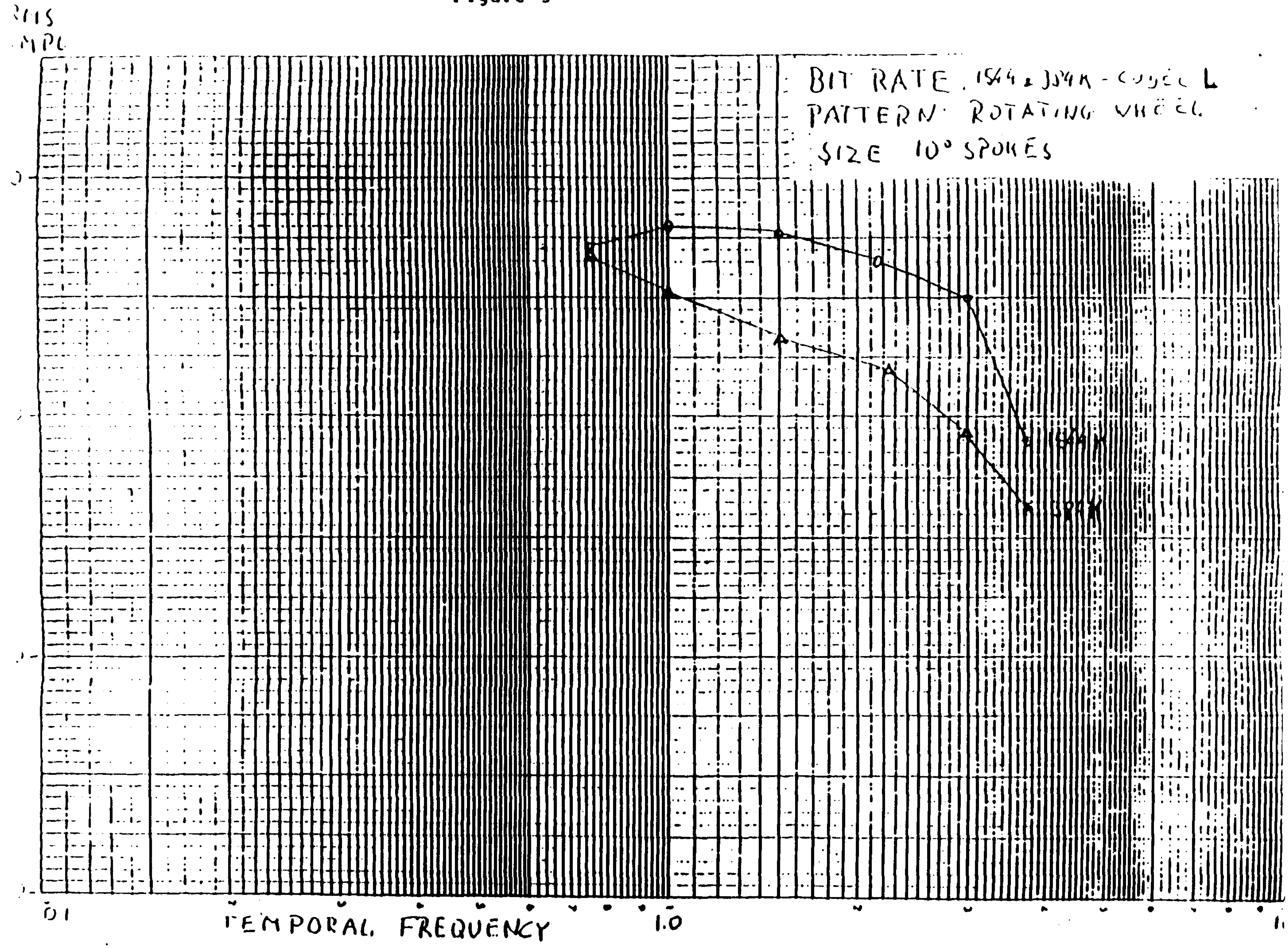
FIGURE 2

Figure 3



RMS
AMPL
BIT RATE . 384K
PATTERN: ROTATING
SIZE: 18° SPOKES
384
56
.01
1.0
TEMPORAL FREQUENCY

Figure 5


BIT RATE
PATTERN: ROTATING WHEEL
SIZE 10° SPOKES
1544K
.01
1.0
TEMPORAL FREQUENCY

APPENDIX F4

COMMITTEE T1
CONTRIBUTION

DOCUMENT NUMBER: T1Q1.5/89-112

****

STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

****

TITLE: IMAGE UPDATE TIME

****

ISSUE ADDRESSED: A CATALOGUE TO PROVIDE ARTIFACT NAMES, DEFINITIONS, PARAMETERS, AND REFERENCES.

****

SOURCE: DELTA INFORMATION SYSTEMS, INC.
HORSHAM BUSINESS CENTER,
300 WELSH ROAD, BLDG. 3
HORSHAM, PENNSYLVANIA 19044
USA

****

DATE: 07-25-89

****

DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

****

KEYWORDS: Video, Teleconferencing, Telephony, Artifacts, Definitions, and Parameters.

****

DISCLAIMER:

IMAGE UPDATE TIME

1. Background

In videoconferencing and videophone systems there is typically an "update" mode of operation when the output image must change to a totally new picture as rapidly as possible. For example, this mode occurs when a camera switch is introduced. When this occurs an artifact appears which is particularly visible at low bit rates. The artifact may take the form of blocking and/or blurring, etc.

2. Proposal

It is proposed that one measurement of the loss of temporal resolution be the measurement of "image update time". One possible test procedure would be that listed below.

a. Start with a black field.

b. Switch to a pattern of multiple white circles.

c. Measure the number of TV frames which is required to achieve 90% of full brightness on the circles.

This measurement has the following advantages:

- has direct operational meaning and value
- relatively simple to measure

APPENDIX F5

COMMITTEE T1Q1.5

CONTRIBUTION

DOCUMENT NUMBER: T1Q1.5/89

....

STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

....

TITLE: IMAGE UPDATE TIME

....

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SOURCE: DELTA INFORMATION SYSTEMS, INC.
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DATE: OCTOBER 17, 1989

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KEYWORDS: VIDEO, TELECONFERENCING, SWITCHING, ARTIFACTS, DEFINITIONS, AND PARAMETERS

....

DISCLAIMER:

IMAGE UPDATE TIME

1. BACKGROUND

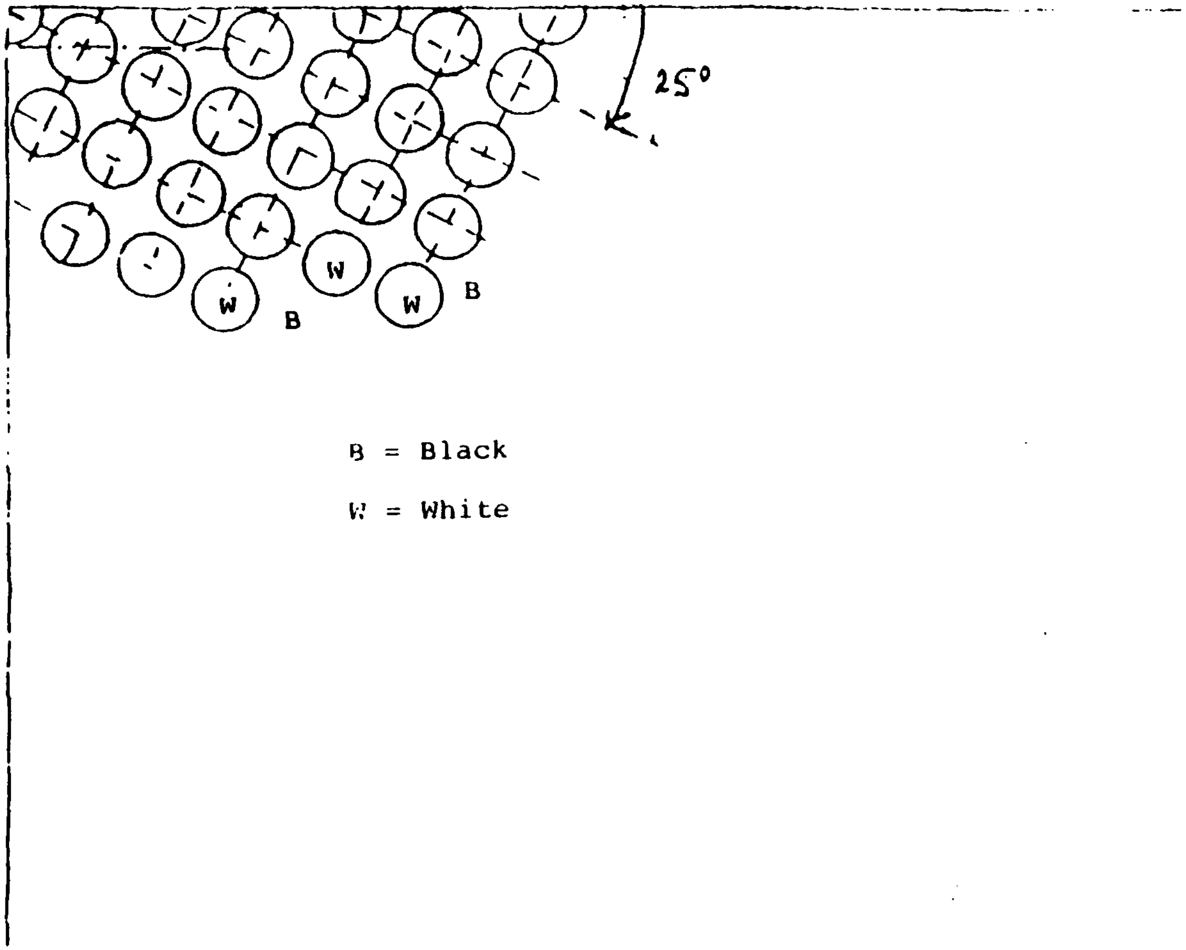
This contribution is a follow-up to Document No. T1Q1.5/89-112, dated 07-25-89. In videoconferencing and videophone systems there is typically an "update" mode of operation when the output image must change to a totally new picture as rapidly as possible. For example, this mode occurs when a camera switch is introduced. In this case, an artifact appears which is particularly visible at low bit rates. The artifact may take the form of blocking, blurring, retention of the previous picture, etc.

A parameter called "settling time" has been previously introduced by manufacturers of low bit rate codecs. It is used in case of a rapid change of scene content as causec for instance by fast motion and adjustment of graphic material before a camera. So far it could only be estimated subjectively but it is essentially identical with update time for which an objective measurement technique is presented herein.

2. MEASUREMENTS

Measurements of image update times were performed in accordance with the proposal contained in the above referenced document. They employed a previously produced test tape designed to investigate methods of determining the temporal frequency response of video codecs. It had been processed through two codecs at three different bit rates each.

The test pattern used for these measurements is shown on Figure 1. It consists of white circles on a black background alternating with black fields. In



B = Black

W = White

FIGURE 1:CIRCLE PATTERN

order to minimize possible repetition of blocks subjected to transform coding. the axis connecting the centers of the circles is tilted 25 degrees against the horizontal. The switching interval is 4 seconds or 120 frames which is sufficient to measure even the longest update times. Three different circle sizes and spacings are used. The percentage of pixel change is kept to about 60% for all sizes but the average numbers of transitions (black-white or vice versa) on each line are 28 for the large, 46 for the medium, and 80 for the small circles. Thus the three circle patterns produce different amounts of challenge on the codec algorithm.

The measurements were implemented by playing the processed 3/4" test tape in a Sony VO-9850 Video Cassette Recorder. This equipment features a frame counter and a jog mode which allows manual frame-by-frame movement of the tape. The output picture was viewed on a Sony CVM-1900 Monitor and analyzed on a Tektronix VM-700 Video Measurement Set. The monitor is very desirable while experimenting with the measurement methodology but will ultimately not be needed. The VM-700 allows accurate measurement of the video amplitude at any defined point in the picture.

As expected, the switch from all black to the white circle pattern proved to be most useful. Switching to a high detail picture is more challenging to the codec than a switch in the reverse direction. Both codecs under test show at least a slightly lower video level immediately following the switching but there are significant differences between the two equipments. Codec A, operating at 56, 128 and 384 Kbps, achieves a uniform full output level in two or three discrete steps. When three steps are needed, the second intermediate step shows a distinct difference between top and bottom of the picture, therefore measurements on lines No. 25 and 255 were made. Codec B, operating at 384, 768 and 1544 Kbps, produces a complex pattern of artifacts which, in addition to reduced video levels, shows interaction between the white circle pattern and the block coding of the codec algorithm. This feature is more pronounced in the bottom half of the picture. So far measurements were made near top, center and bottom near the horizontal center but ideally a much larger number of locations should be examined and averaged. This will require an automated measurement technique which is planned to be developed in the future.

3. RESULTS AND DISCUSSION

The results of all measurements are compiled on Tables 1 and 2 for codecs A and B. All readings were taken at the first frame at which a change was noticeable. There was no more change beyond the highest number frame listed. The differences between the two codecs are obvious. Codec A achieves full output in discrete steps, with 3 steps necessary at 56 and 128 Kbps when the medium and small circles are used. At the intermediate step most of the picture is updated to the full level with exception of a small distinctly delineated area in the bottom The level changes in Codec B are less pronounced and at 384 Kbps more difficult to measure because of the interaction with artifacts produced by block coding. There are some additional minor artifacts which cause small level uncertainties of about ± 2 IRE Units but do not affect the validity of the results.

The measurement results are summarized in the six simple graphs on Figure 2. The update time is defined as the number of frames necessary after switching to achieve 100% output level. This definition gives the widest range of useful data which are fully consistent in their relation to other system parameters. As expected, the update time increases at lower data rates and with increasing challenge on the codec algorithm produced by smaller circles. Each codec has almost perfect performance at its highest data rate.

A comparison of the two tested codecs is possible at the common data rate of

384 Kbps. This was done subjectively during equipment demonstrations when both codecs were operating side-by-side. The unanimous opinion of the observers was that at 384 Kbps codec A (with its algorithm optimized for low data rates) gave superior performance. The same is brought out clearly in the graphs of Figure 2. This shows full correlation between the update time measurement and subjective evaluation.

4. CONCLUSION

The method of analyzing the update time of a codec following a scene cut has been verified experimentally. Very similar to the numerical temporal response, the update time describes the motion rendition capability of a codec. Results show the same relations between both update time and temporal resonse and other parameters, such as bit rate and the challenge of the test pattern on the codec algorithm.

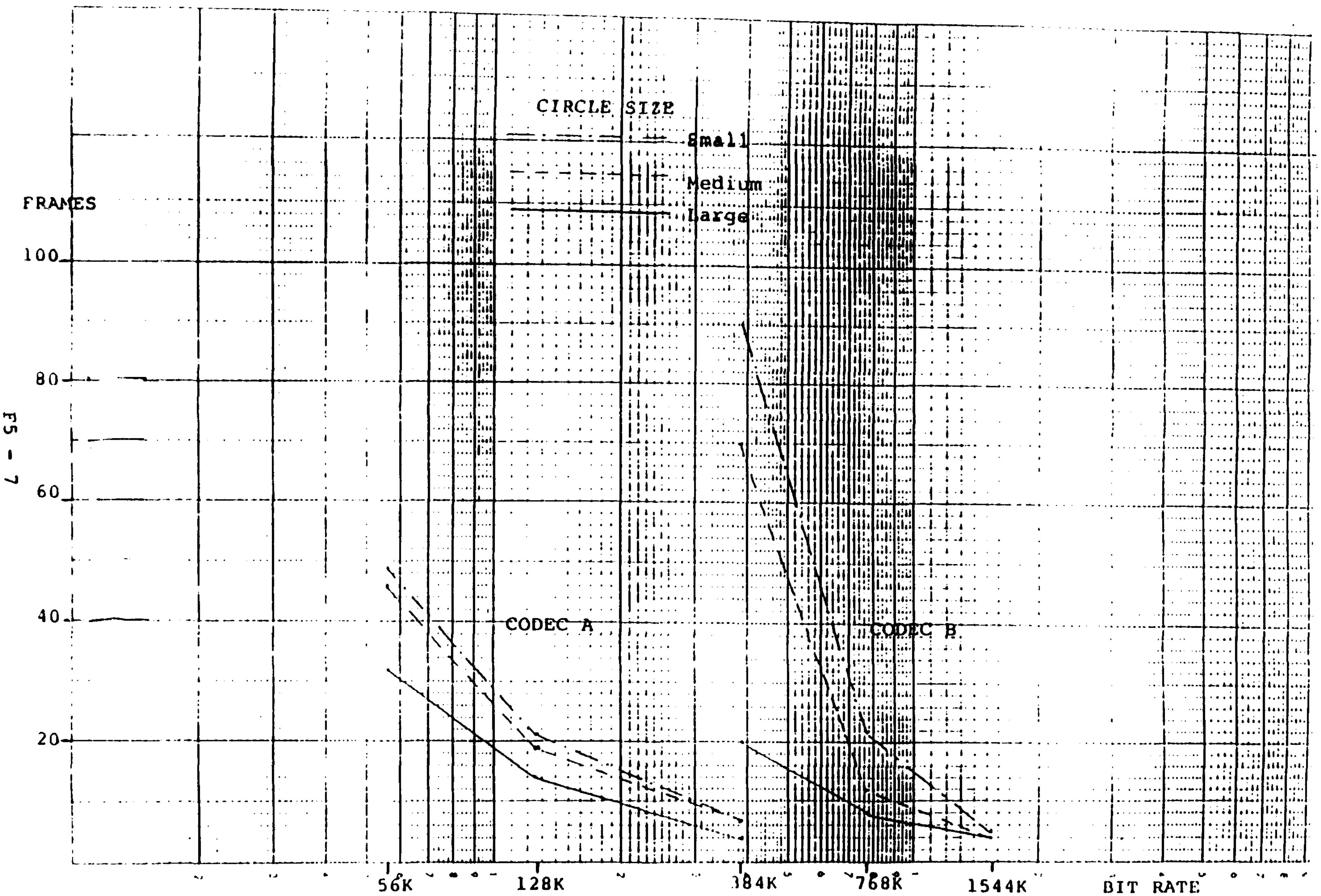


FIGURE 2: NUMBER OF FRAMES REQUIRED FOR 100% UPDATE

CODEC A MEASUREMENTS

CIRCLE SIZE	BIT RATE	FRAME NO	LINE NO	AMPL (IRE)	% OF FULL
LARGE	56K	0	ANY	60	72
		32	ANY	83	100
	128K	0	ANY	64	78
		14	ANY	82	100
	384K	0	ANY	62	78
		4	ANY	80	100
MEDIUM	56K	0	ANY	37	44
		34	25 255	85 36	100/ 42
		46	ANY	85	100
	128K	0	ANY	49	60
		16	25 255	81 46	100/ 57
		19	ANY	81	100
	384K	0	ANY	62	77
		7	ANY	81	100

TABLE 1, SHEET 1

CODEC A MEASUREMENTS

CIRCLE SIZE	BIT RATE	FRAME NO	LINE NO	AMPL (IRE)	% OF FULL
SMALL	56K	0	ANY	47	59
		36	25 255	82 47	102/ 59
		49	ANY	80	100
	128K	0		46	58
		17	25 225	80 47	100/ 59
		21	ANY	80	100
	384K	0	ANY	60	77
		7	ANY	79	100

TABLE 1, SHEET 2

CODEC B MEASUREMENTS

CIRCLE SIZE	BIT RATE	FRAME NO	LINE NO	AMPL (IRE)	AVG.	% OF FULL
LARGE	384K	0	25 150 255	70 66 65	67	80
		1	25 150 255	83 80 78	80	95
		4	25 150 255	83 83 81	82	98
		8	25 150 255	83 83 83	83	99
		20	25 150 255	84 84 84	84	100
	768K	0	25 150 255	75 70 73	73	90
		2	25 150 255	81 79 77	79	98
		8	25 150 255	81 81 81	81	100
	1544K	0	25 150 255	75 73 71	73	96
		2	25 150 255	76 75 74	75	99
		4	25 150 255	76 76 76	76	100

TABLE 2, SHEET 1

CODEC B MEASUREMENTS

CIRCLE SIZE	BIT RATE	FRAME NO	LINE NO	AMPL (IRE)	AVG.	% OF FULL
MEDIUM	384K	0	25 150 255	65 65 59	63	73
		2	25 150 255	76 76 70	74	86
		4	25 150 255	80 90 84	85	99
		70	25 150 255	86 86 86	86	100
	768K	0	25 150 255	80 80 73	78	92
		2	25 150 255	84 85 83	84	99
		12	25 150 255	86 85 85	85	100
	1544K	0	25 150 255	76 76 66	73	95
		4	25 150 255	77 78 75	77	100

TABLE 2, SHEET 2

CODEC B MEASUREMENTS

CIRCLE SIZE	BIT RATE	FRAME NO	LINE NO	AMPL (IRE)	AVG.	% OF FULL
SMALL	384K	0	25 150 255	66 59 56	60	74
		2	25 150 255	71 71 62	68	84
		21	25 150 255	72 85 72	77	95
		90	25 150 255	82 80 80	81	100
	768K	0	25 150 255	73 71 68	71	89
		2	25 150 255	74 83 74	77	96
		22	25 150 255	80 80 81	80	100
	1544K	0	25 150 255	74 76 74	75	95
		5	25 150 255	79 80 79	79	100

TABLE 2, SHEET 3

APPENDIX F6

COMMITTEE T1Q1.5
CONTRIBUTION

Document Number: T1Q1.5/90-109 Rev. 01

****

STANDARDS PROJECT:	ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

****

TITLE:	TRANSMITTED FRAME RATE

****

ISSUE ADDRESSED:	A CATALOGUE TO PROVIDE ARTIFACT NAMES, DEFINITIONS, PARAMETERS, AND REFERENCES.

****

SOURCE: DELTA INFORMATION SYSTEMS, INC.
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DATE:	APRIL 24, 1990

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DISTRIBUTION TO:	T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

****

KEYWORDS: VIDEO, TELECONFERENCING, ARTIFACTS, JERKINESS, DEFINITIONS, AND PARAMETERS

****

DISCLAIMER:

TRANSMITTED FRAME RATE

All teleconferencing codecs reduce the total amount of transmitted information by deleting frames from transmission, thus producing an effective frame rate below 30 frames/sec. At bit rates above 384 Kbps the transmitted frame rate is typically 15 frames/sec. At lower bit rates the frame rate can drop below 5 frames/sec. This rate is usually adaptive, changing automatically with picture content and amount of motion.

This lowered transmitted frame rate requires repetition of frames at the receiver to re-constitute the TV signal and produces the motion artifact known as jerkiness. The purpose of this contribution is to propose the use of the parameter "Transmitted Frame Rate" as a practical measure of this motion distortion in teleconferencing systems. The Transmitted Frame Rate (TFR) is directly related to the amount of jerkiness, and its measurement has the following advantages:

- It describes the jerkiness of an actual whole picture while the method of computing the RMS value of position errors as proposed in Document No. T1Q1.5/89-119 depends on one object introduced in a special test scene. That measured jerkiness changes with the arbitrarily chosen speed of the test object and thus bears no direct relation to the performance capability of the codec algorithm.

- TFR is easily measured. For instance, the test procedure DIS has used to measure Temporal Frequency Response gives its value as a by-product, but other similar methods can be established using any test picture. It does not require a special test scene and mathematical analysis to produce a meaningful measure of jerkiness.

Measurement of the transmitted frame rate requires a tape recorder with manual advance (jog mode) and frame counter and a waveform monitor with line selector. A Sony VO-9850 3/4" recorder and a TEK VM-700 Video Measurement Set provide a very convenient test setup but a less sophisticated waveform monitor is fully adequate. A picture monitor is useful only to identify the test pattern, it is not needed for the performance of the measurement which is purely objective. Observing the conveniently expanded waveform using the accurately positioned cursor while manually advancing the tape of a motion scene recorded at the codec output makes it easy to identify the frames at which a change in the picture occurs. The number of frames between these changes gives the frame repetition rate (FRR) and thus (by dividing this number into 30) the transmitted frame rate (TFR).

In practice this measurement has been performed as part of the analysis of temporal response implemented with a rotating wheel but any other smoothly moving picture can be used. At each change in pattern both frame number and picture amplitude are noted. A computer program gives the RMS value of the amplitudes over a range of rotation speeds of the same pattern and the average distance (in frames) of measurement points. Both these numbers are used for the temporal frequency response measurement, therefore, the frame repetition rate is obtained as a by-product without extra effort. Apart from negligible slight inaccuracies, this average distance is a whole number of frames but if the frame repetition is adaptive it may assume any fractional value.

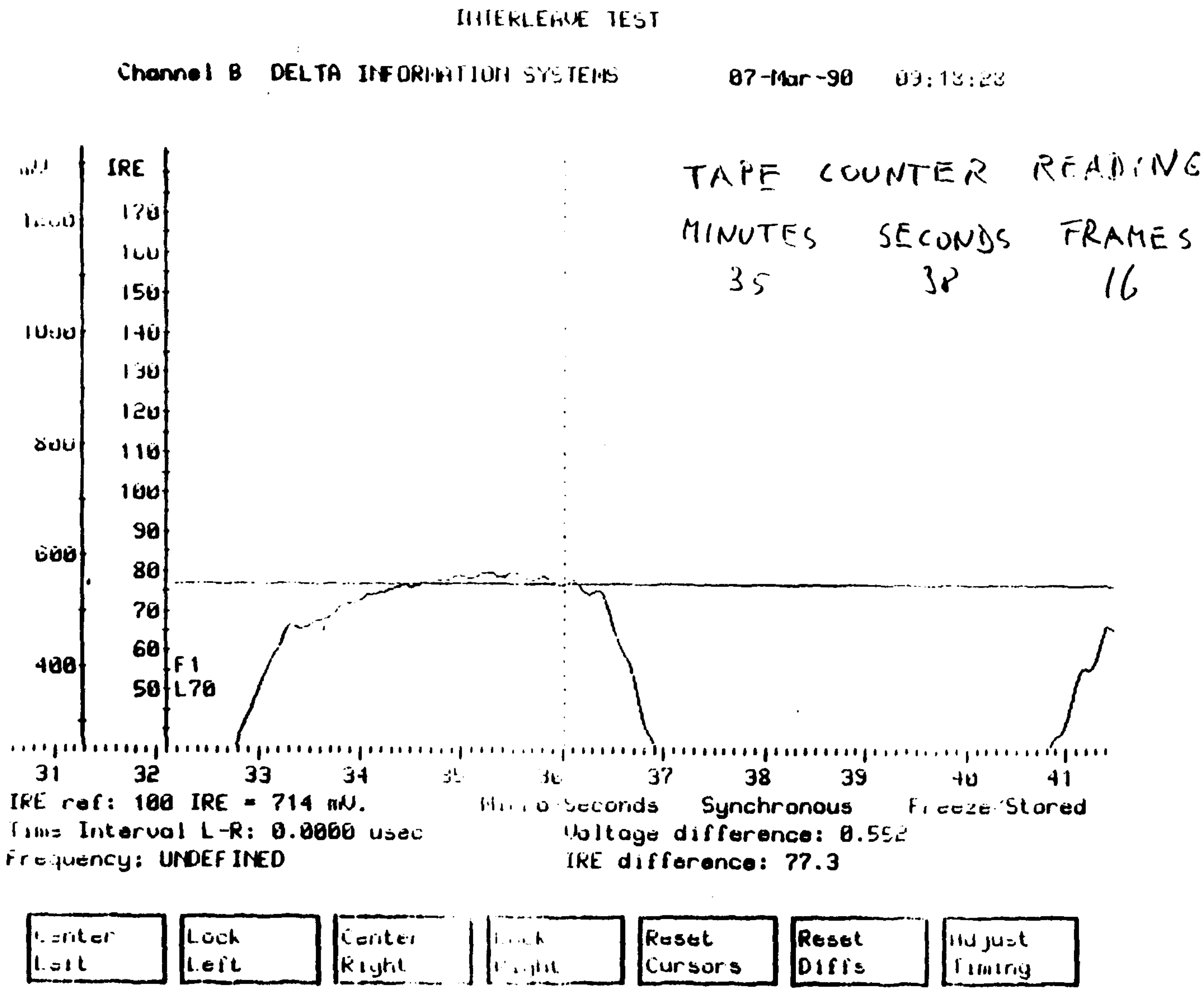
This value exactly describes the observed jerkiness which is a fairly long time average phenomenon and therefore requires the analysis of a large number of frames over several seconds which is provided by this method.

The following 7 figures illustrate as a sample a portion of the measurement of temporal response and FRR at 128 Kbps with motion test pattern No. 12 which imposes an average stress on the codec. Each figure shows the printout of a VM-700 waveform immediately following an advance. The motion between two consecutive patterns is so obvious that there is no risk of overlooking the change. Each printout has the tape counter reading at the moment noted on it. The range covered by the sample figures is one temporal cycle and lasts 34 frames. The distances between advances vary between 4 and 7 frames which clearly shows the adaptivity of the frame repetition feature. The resulting FRR is 5.67 and the TFR 5.29. Figure 8 shows the computer evaluation of the same test pattern over the longer period of 154 frames or just over 5 seconds. It results in an average FRR of 6.12 and a TFR of 4.90 below 5, showing the severe jerkiness produced by the motion test pattern at 128 Kbps. The period of 5 seconds is long enough to make the result realistic when compared with the subjective visual perception of any observer.

Looking into the future, CCITT Draft Recommendation H.261 (see Document T1Q1.5/89-113) states that the maximum picture rate is to be restricted by having at least 0, 1, 2, or 3 non-transmitted pictures between transmitted ones. This inherently allows the considerable jerkiness caused by a TFR of 7.5/sec. and possibly lower. A TFR below 24 is the only experimentally confirmed cause of jerkiness. Should a future codec algorithm allow accurate location interpolation of non-transmitted frames instead of simple frame repetition, a measured TFR of 30 would result and no jerkiness would be noted. In the unlikely case that a teleconferencing codec may ever have different frame rates in different parts of the picture area, this method of TFR measurement can readily be applied because the measurement location can be pinpointed to one line vertically and to less than one microsecond horizontally.

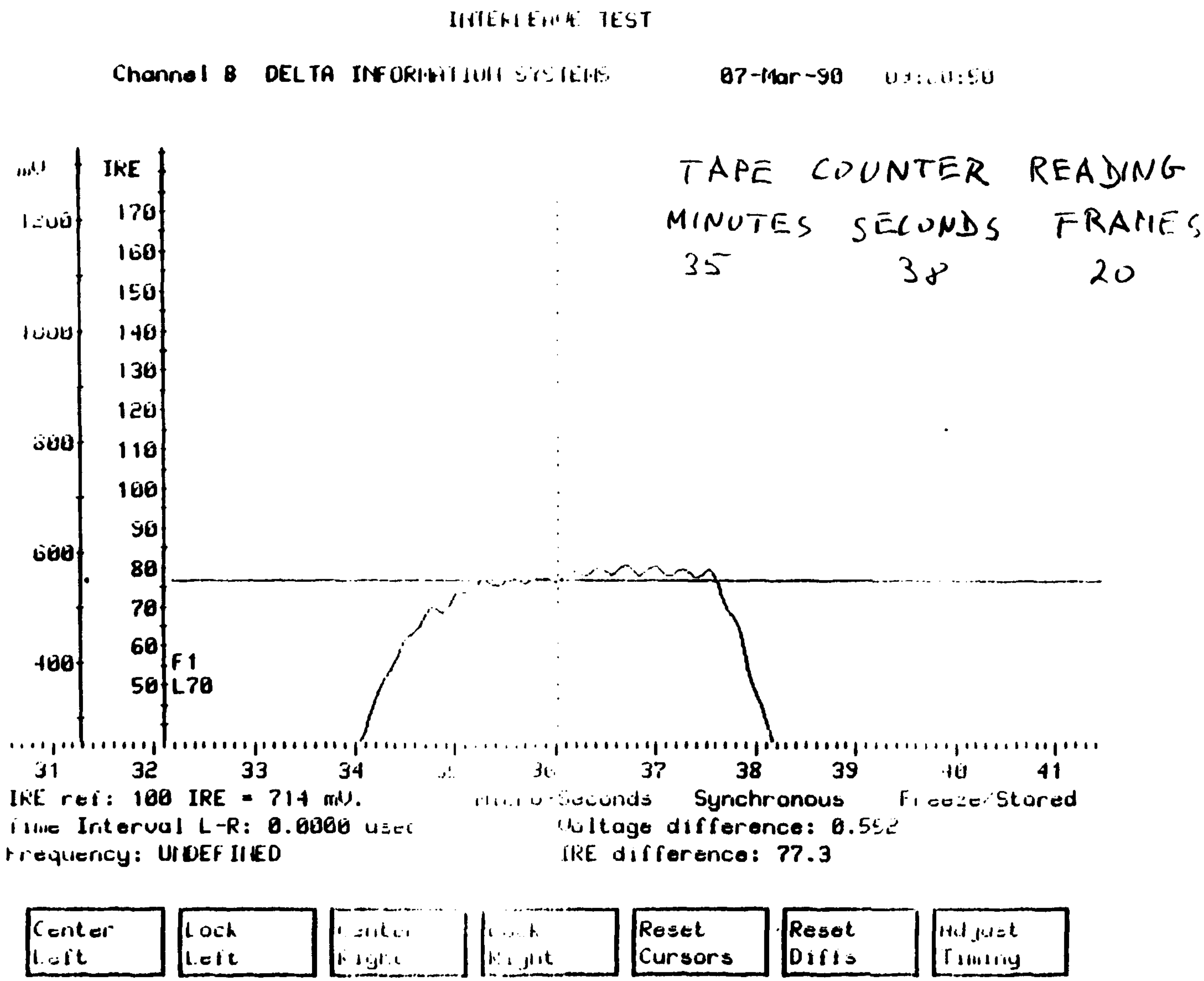
A review of the numerous results contained in Document T1Q1.5/89-119, updated in Document T1Q1.5/90-108 shows that under all conditions of bit rates and speed and direction of motion the measured jerkiness is caused exclusively by the repetition of every other frame. Therefore, the only meaningful result is a TFR of 15 which is a basic design parameter of the codec at all operating bit rates and usually contained in the equipment specifications. This value is typical for all codecs operating in the 384 to 1544 Kbps range. The measured jerkiness is shown to be exactly proportional to the speed of motion which is an obvious and logical result and independent of the algorithm of the codec under test. Thus, a sophisticated measurement method gives valid results but involves much unnecessary effort and complexity.

Evaluation of jerkiness of codecs operating in the range of 64 to 384 Kbps is a more challenging task. In order to reproduce sufficient detail of a moving picture at a low bit rate more time than 1/15 second is required to transmit each frame unless the test picture is unrealistically simple. Depending on picture content and speed of motion, the TFR has to be reduced below 15. In order to reach an optimum compromise between picture detail and jerkiness, the TFR is made adaptive in all low bit rate codecs which have been tested. The number is not constant but changes depending on transmit buffer fullness. This is illustrated in Figures 9 and 10 which show the computer analysis of test patterns number 1 and 11 after processing through the same codec at 64 Kbps. Both patterns have the same rotation speed but pattern 11 has more detail. Pattern 1 results in an average FRR of 6.81 while pattern 11 requires an FRR of 10.41. These numbers correspond to TFR values of 4.41 and 2.88, resulting in severe jerkiness. The analysis of pattern 1 was performed over 253 frames or 8.4 seconds, and of pattern 11 over 230 frames or 7.7 seconds. These numbers are sufficiently high for the measured TFR to exactly describe the jerkiness as perceived by a visual observer.



INTERLEAVE TEST
Channel B DELTA INFORMATION SYSTEMS 07-Mar-90
TAPE COUNTER READING
MINUTES SECONDS FRAMES
35 38 16
mV
IRE
1000
800
600
400
170
150
140
130
120
110
100
90
80
70
60
50
F1
L70
31 32 33 34 36 37 38 39 41
IRE ref: 100 IRE = 714 mV.
Synchronous
Freeze Stored
Time Interval L-R: 0.0000 usec
Voltage difference: 0.552
Frequency: UNDEFINED
IRE difference: 77.3
Lock Left
Center Right
Reset Cursors
Reset Diffs
Adjust Timing

FIGURE 1



Channel B DELTA INFORMATION SYSTEMS
07-Mar-90
TAPE COUNTER READING
MINUTES SECONDS FRAMES
35 38 20
IRE
170
160
150
140
130
120
110
100
90
80
70
60
50
600
400
F1
L70
31
32
33
34
37
38
39
41
IRE ref: 100 IRE = 714 mV.
Synchronous
Time Interval L-R: 0.0000 usec
Voltage difference: 0.592
Frequency: UNDEFINED
IRE difference: 77.3
Center
Left
Lock
Left
Reset
Cursors
Reset
Diffs

FIGURE 2

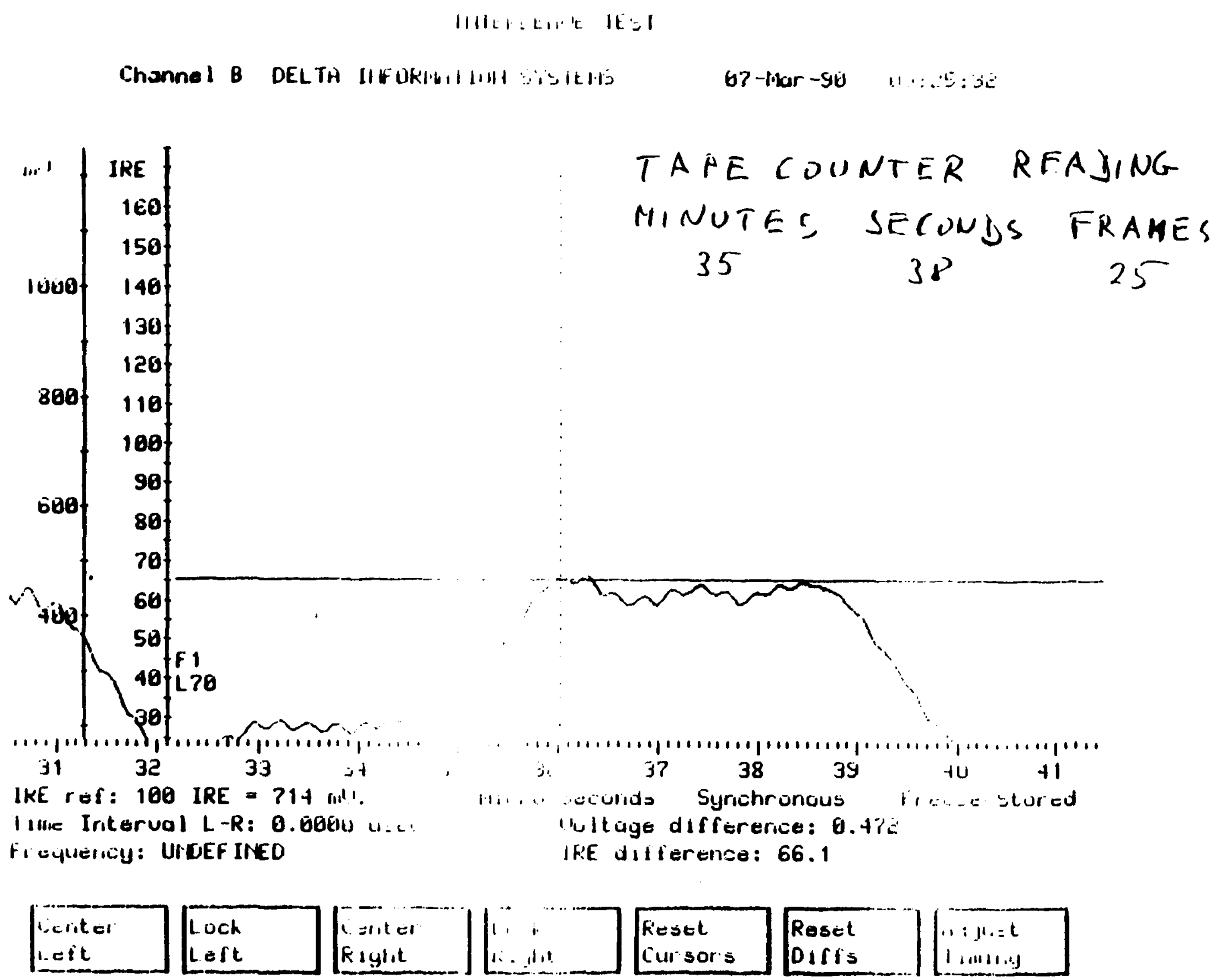
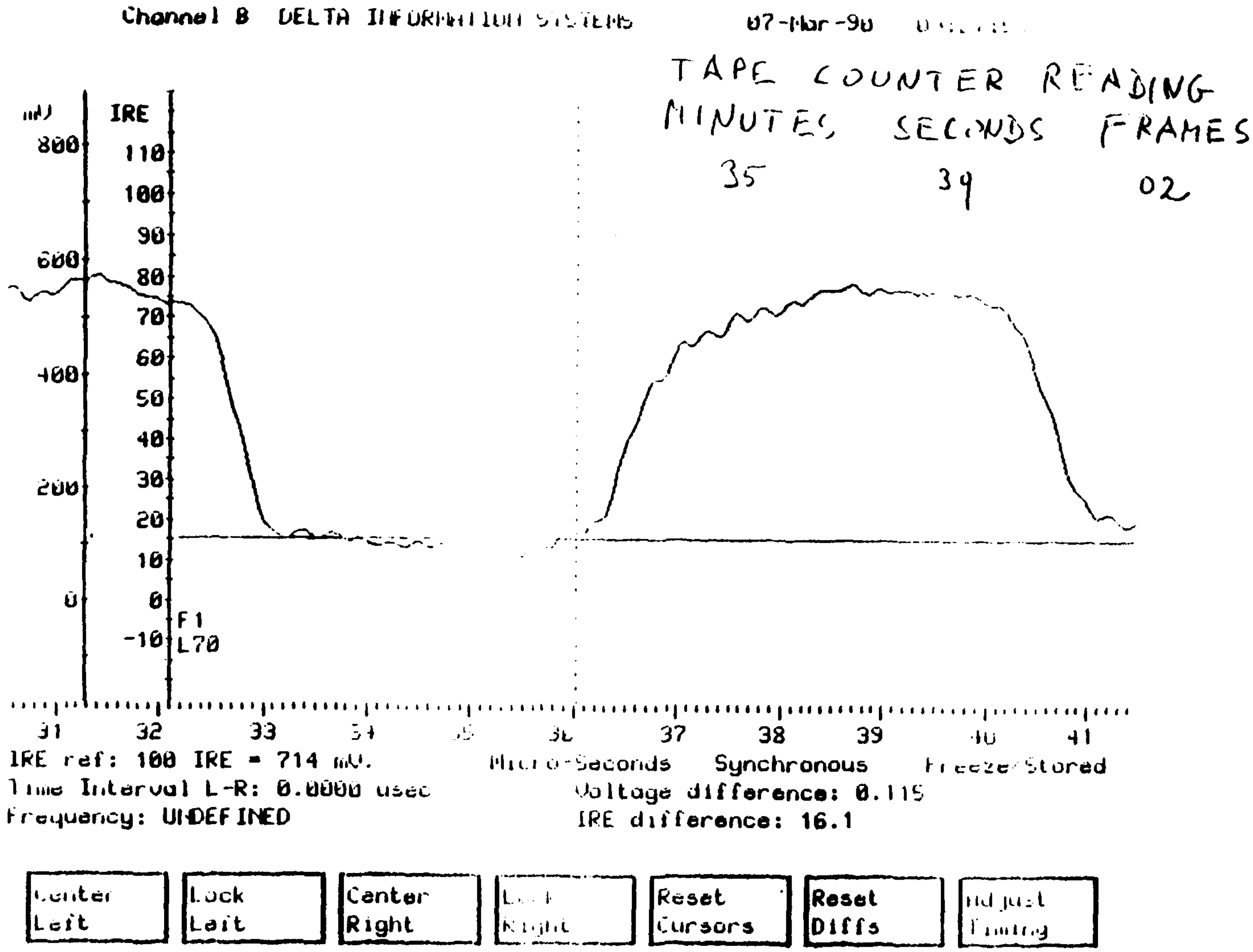

Channel B DELTA INFORMATION SYSTEMS 07-Mar-90
TAPE COUNTER READING
MINUTES SECONDS FRAMES
35 38 25
IRE
160
150
140
130
120
110
100
90
80
70
60
50
40
30
1000
800
600
400
F1
L70
31 32 33 37 38 39 41
IRE ref: 100 IRE = 714
Interval L-R: 0.0000
Frequency: UNDEFINED
Synchronous
Voltage difference: 0.472
IRE difference: 66.1
Lock Left
Right
Reset Cursors
Reset Diffs

FIGURE 2

INTERLEAVE TEST

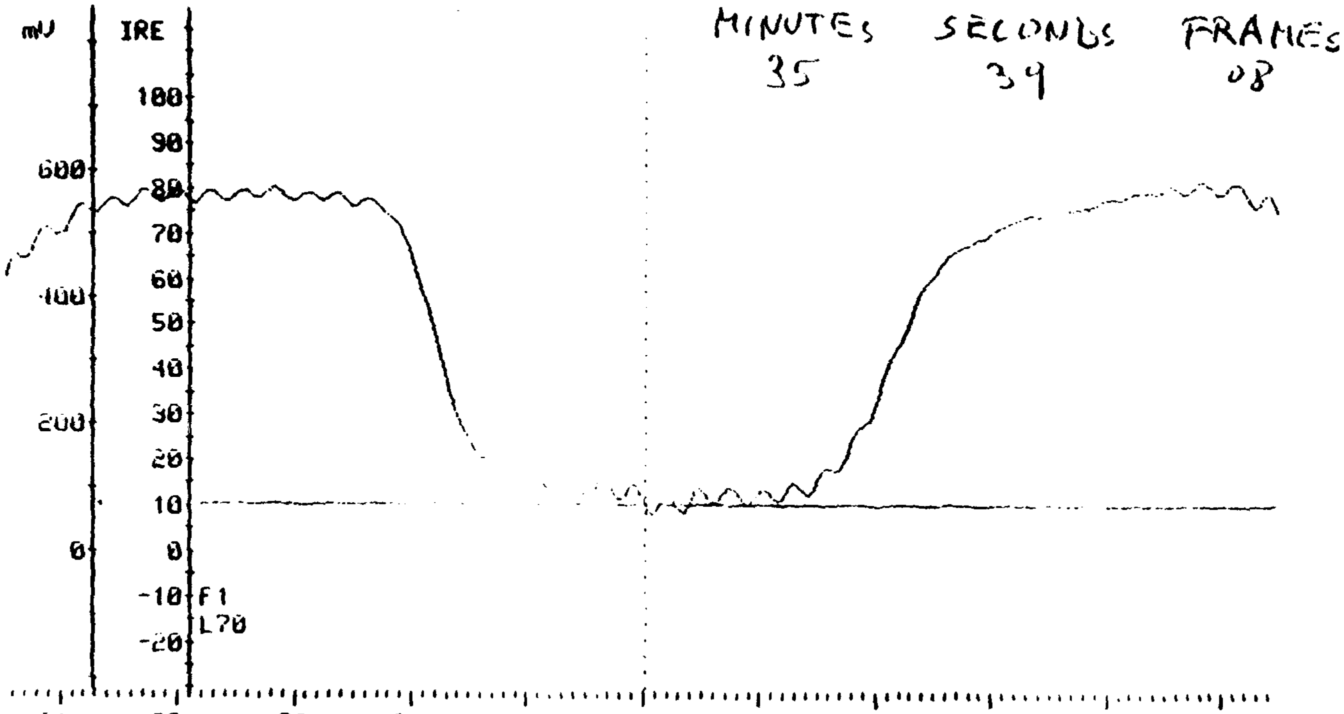


FIGURE

INTERLEAVE TEST

Channel 6 DELTA INFORMATION SYSTEMS 07-Mar-90 03:30:44

TAPE COUNTER READING
MINUTES SECONDS FRAMES
35 39 08



IRE ref: 100 IRE = 714 mV. Micro-Seconds Synchronous Freeze Stored
Time Interval L-R: 0.0000 usec Voltage difference: 0.073
Frequency: UNDEFINED IRE difference: 10.9

Center Left	Lock Left	Center Right	Lock Right	Reset Cursors	Reset Diffs	Adjust Timing

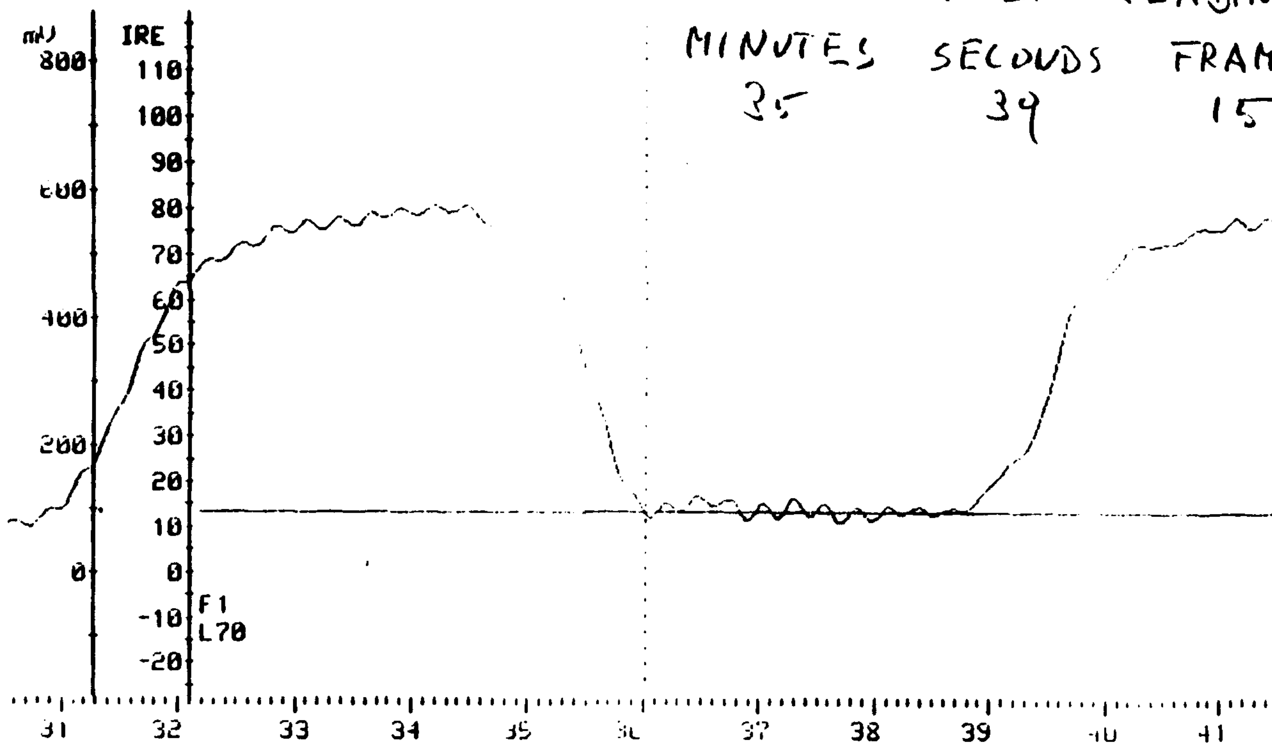
FIGURE 6

INTERLEAVE TEST

Channel 6 DELTA INFORMATION SYSTEMS 07-Mar-90 03:52:42

TAPE COUNTER READING

MINUTES	SECONDS	FRAMES
35	39	15



IRE ref: 100 IRE = 714 mV. Microseconds Synchronous Freeze Stored

Time Interval L-R: 0.0000 usec Voltage difference: 0.099

Frequency: UNDEFINED IRE difference: 13.9

Center Left	Lock Left	Center Right	Lock Right	Reset Cursors	Reset Diffs	Adjust Timing

FIGURE 6

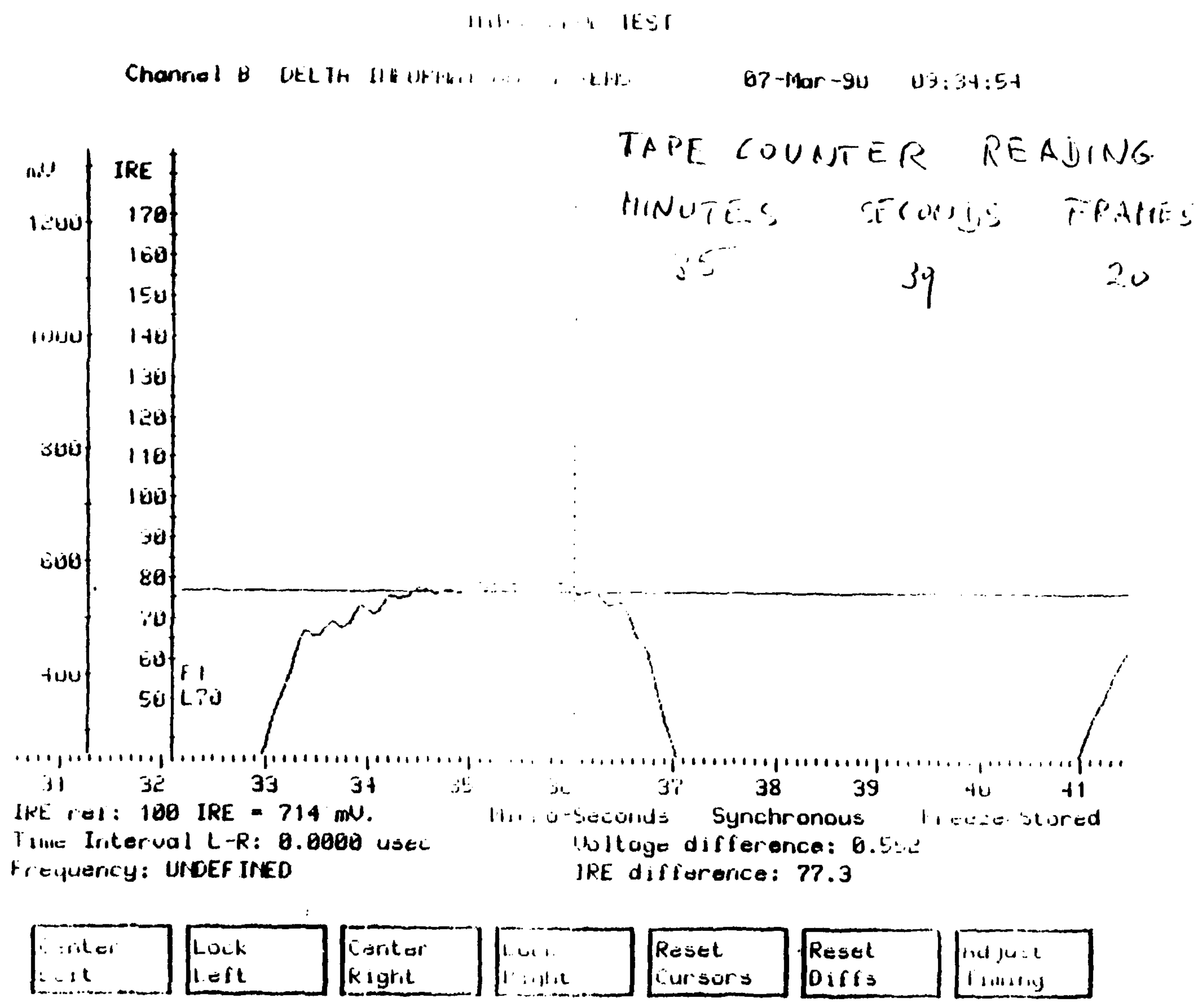

TEST
Channel B DELTA
07-Mar-90 03:34:54
TAPE COUNTER READING
MINUTES SECONDS FRAMES
35 39 20
mV
IRE
1200
1000
800
600
400
170
160
150
140
130
120
110
100
90
80
70
60
50
F1
L70
31
32
33
34
35
37
38
39
40
41
IRE ref: 100 IRE = 714 mV.
Time Interval L-R: 0.0000 usec
Frequency: UNDEFINED
Synchronous
Voltage difference: 0.552
IRE difference: 77.3
Lock
Left
Center
Right
Reset
Cursors
Reset
Diffs

FIGURE 7

APPENDIX G

ANNEX A

TELECONFERENCING PICTURE FORMATS

ORGANIZATION	RECOMMENDATION	BIT RATE		LUMINANCE PELS/LINE	LUMINANCE LINES/FRAME	CHROMINANCE PELS/LINE	CHROMINANCE LINES/FRAME
PRIMARY RATE							
TYPICAL NTSC MFRS.	-	1.544/768		368	480	92	120
CCITT	H.120	2.048		256	286	128	143
CCITT	H.261	Nx384		352	288	176	144
SUB RATE							
TYPICAL NTSC MFRS.	-	56/112		256	240	64	60
CCITT	H.12Y	Mx64	(GOAL)	352	288	176	144
			(RQD)	180	144		
			(US)	256	240		
			(JAPAN)	240	192		
T1Y1.1		Mx64	(RQD)	180	144	45	72
			(OPT)	256	240	64	120

APPENDIX H

COMMITTEE T1
CONTRIBUTION

DOCUMENT NUMBER: T1Q1.5/90-

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STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

****

TITLE: STILL PICTURE VIDEO PERFORMANCE PARAMETERS

****

ISSUE ADDRESSED: THE NEED FOR STANDARDIZING STILL PICTURE (SPATIAL) PERFORMANCE PARAMETERS

****

SOURCE: DELTA INFORMATION SYSTEMS, INC.
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DATE: October 16, 1990

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DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

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KEYWORDS: VIDEO, TELECONFERENCING, STILL PICTURE, RESPONSE AND PARAMETERS.

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DISCLAIMER:

1. <u>BACKGROUND</u>

This contribution was initiated in discussions during the audio conference on September 10, 1990. The point in question is the necessity and usefulness of including standards for conventional video parameters (based on still picture measurements) in the Standard for Video Teleconferencing/Video Telephony Service now being prepared by Committee T1Q1.5.

Document T1Q1.5/89-107, REV 03 contains standards for these performance parameters which are based on high quality broadcast requirements. As a matter of fact, most values are identical to the performance specifications for short haul (single link) microwave transmission stated in EIA Standard RS-250B. However, more recently it has been recognized and acknowledged that the subjective quality rating of a video teleconferencing/videophone system is almost exclusively based on its motion performance which is independent of the factors discussed herein.

Based on the above facts, it has been questioned whether it is necessary or desirable to include values for these still picture (often also called analog or spatial) parameters in the upcoming revision of document T1Q1.5/89-107. This standard is to cover the teleconferencing/videophone system from end to end, as shown schematically in Fig. 1. Two out of three segments of the system including portions of the codecs are analog and thus subjected to "conventional" degradations. This fact alone makes it obvious that still picture (spatial) performance parameters are applicable and valid and must be included in the standard

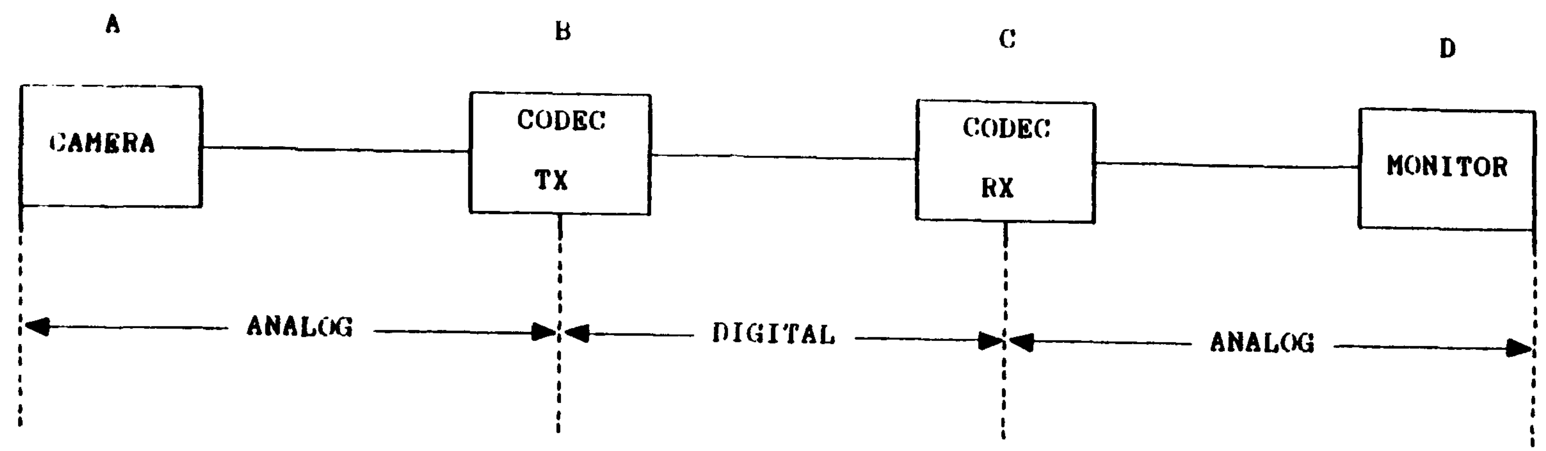


FIGURE 1

TELECONFERENCING/VIDEOPHONE SYSTEM

under development. A video standard not containing conventional video parameters would be incomplete and the system would be left "wide open" to careless practices of codec or system designers. However, experience has shown that many still picture parameters have little impact on the viewer's rating of a teleconferencing picture. After analysis of general circuit properties and measurement results some parameters may be completely eliminated while for the others a rather generous performance tolerance is permissible. As a point of departure, the limits given in EIA RS-250B for end-to-end performance or in NTC Report No. 7 may be considered but this is not a firm proposal at this time.

2. PERFORMANCE PARAMETERS

The two analog links on Figure 1 normally are just short cables which cause no measurable degradation. Long analog video circuits are highly unlikely because their cost would negate the advantage of a teleconferencing system. Therefore, most of the allowable degradation of still picture (spatial) parameters can be allocated to the digital video equipment, the essential portions of which are illustrated on Figure 2. It shows that the still picture performance is determined by the NTSC decoder and encoder and the two filters. The digital portion which processes the three color component signals controls the temporal performance of the system.

The NTSC decoder and encoder which determine most still picture parameters contain only well developed circuits which

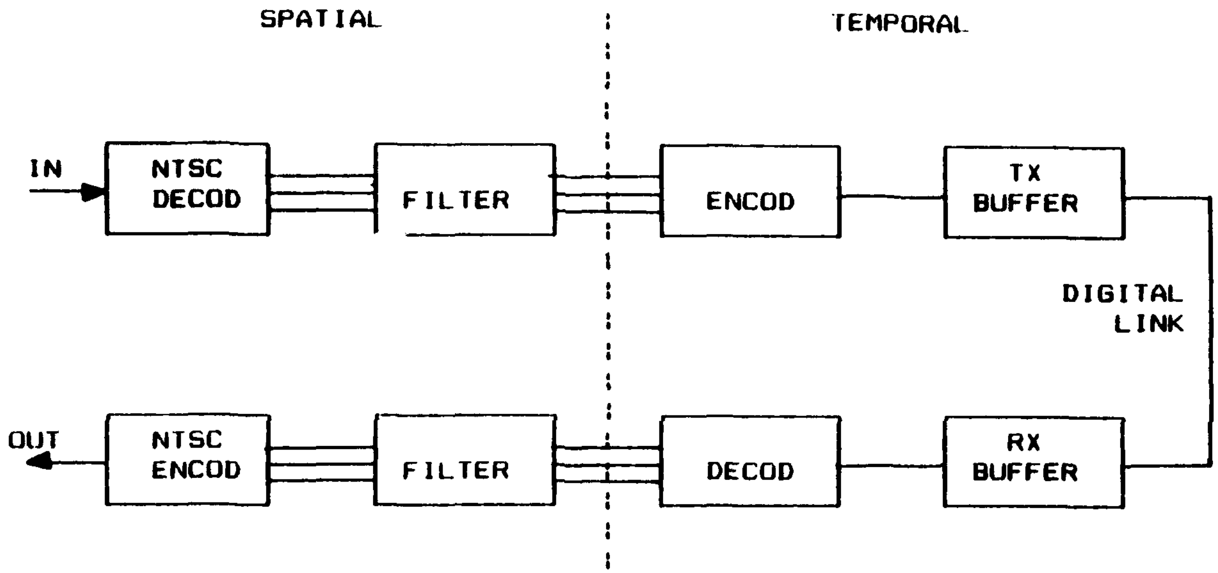


FIGURE 2

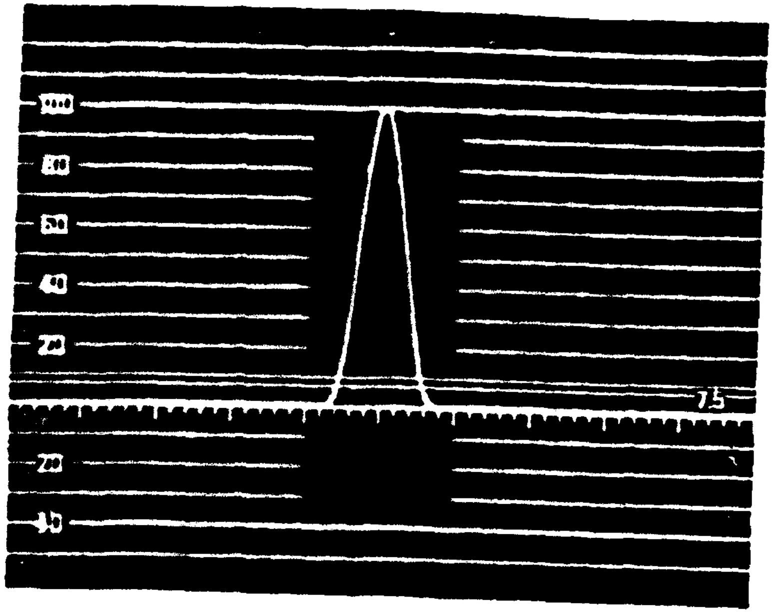
TYPICAL DIGITAL VIDEO SYSTEM

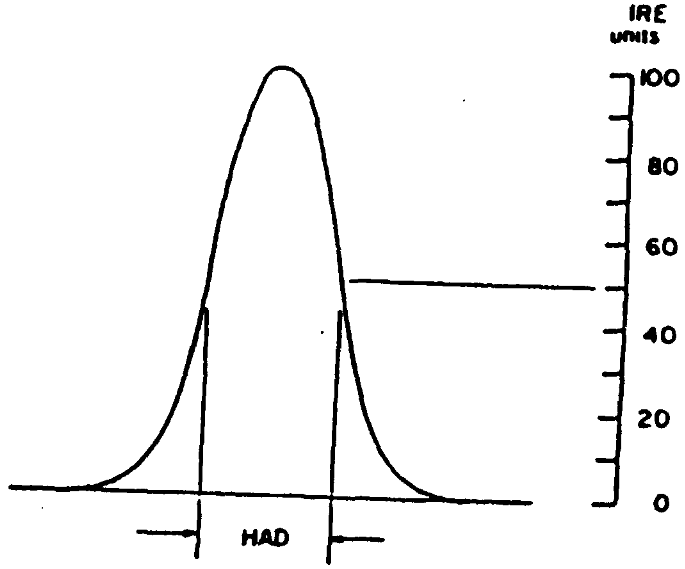
normally give good performance. Since the color subcarrier is not transmitted but regenerated in the receiver, the parameters directly related to it are controlled only by the NTSC encoder. Thus, the amount of analog circuitry in a video codec is considerably less than in any conventional video system. Specifically, both RS-250B and NTC-7 were written at a time when dynamic range and linearity limitations of video circuits such as discriminators could produce serious problems with the transmission of NTSC signals. Since such circuit elements are not present in the systems under consideration, related parameters such as dynamic gain, bounce, and use of average picture levels (APL) other than 50% can generally be omitted. Any serious problem in this area will become obvious as a high value of luminance nonlinearity. Similarly, some recently introduced parameters, such as superstreaking, are only applicable to high quality broadcast video and not to a teleconferencing picture.

The most important still picture parameter which requires careful consideration is frequency response which is determined mainly by the filters shown on Figure 2. The bandwidth of these filters is inherently limited by the sampling rate of the A/D converter in the encoder and the need for smoothing the output of the D/A converter in the decoder. Traditionally, according to the Nyquist rule, the 3dB bandwidth of these filters should be about half the sampling rate but, depending on the ingenuity of the design, sub-Nyquist sampling may allow a slightly higher bandwidth. At any rate, the achievable analog frequency response of a codec is controlled by the properties of its digital circuits, for instance the FCIF and QCIF formats.

It is advantageous to use standard video techniques and test equipment for all still picture measurements. These techniques are well developed and provide accurate results in a minimum of time. Frequency response measurements are normally made with the multiburst signal which has given reasonable results also for digital codecs but some parties have expressed concern about the validity of using a sine wave signal for measurements on a digital system. Though no obvious reason why the multiburst should not be used could be given, it is appropriate to consider alternate methods.

One suggestion was made to use the measure of edge sharpness as described in Document T1Q1.5/90-108 as an indicator of frequency response. This is possible but has the disadvantage of using a "live" picture as test signal which cannot be standardized to give a numerical result which is necessary to establish performance limits. Also, the evaluation requires a relatively complex and time consuming process. However, a standard video test signal is the 2T pulse (see Figure 3) which produces an artificial sharp edge with known waveform dimensions. It can be used to measure the pulse/bar (P/B) ratio which indicates the loss of high frequency response, and the half amplitude duration (HAD) which indicates the reduced sharpness of the pulse. Using modern Tektronix video test equipment, namely





Generator Output Specifications

Peak amplitude	:	100 ± 0.5 IRE units
Half amplitude duration	:	250 ± 10 nanoseconds

FIGURE 3

THE 2T PULSE TEST SIGNAL

the 1910 Signal Generator and the VM-700 Video Measuring Set, the numerical results can be displayed in a matter of seconds as shown in Figure 4. This measurement gives a result related to the critical response range around 2 MHz and above but furnishes only a single point and not a response curve which is required for a full evaluation.

Another suggestion was made to use white noise as a test signal and examine the output on a spectrum analyzer. A more desirable test signal is available in the 1910 Signal Generator in the form of a sinx/x signal going in two directions on a high and a low pedestal as shown on Figure 5. This signal provides a flat spectrum between 15 KHz and 4.5 MHz which exceeds the required measurement range. It also shows up any system nonlinearities. The output can be viewed on a spectrum analyzer, or a response curve can be displayed on the VM-700 as shown on Figure 6 for the unprocessed generator output. The cursor provides a numerical response reading at any desired frequency. Tests by Tektronix have proven multiburst and sinx/x tests to be well correlated. A signal with a narrower spectrum is not presently available but could be provided if needed.

Signal-to-noise measurements have been performed in a conventional manner on a flat field with different levels. In order to also analyze quantizing noise, it would be desirable to use a shallow ramp signal instead and eliminate the low frequency content (tilt) before measuring the noise. This method requires further investigation before it can be implemented.

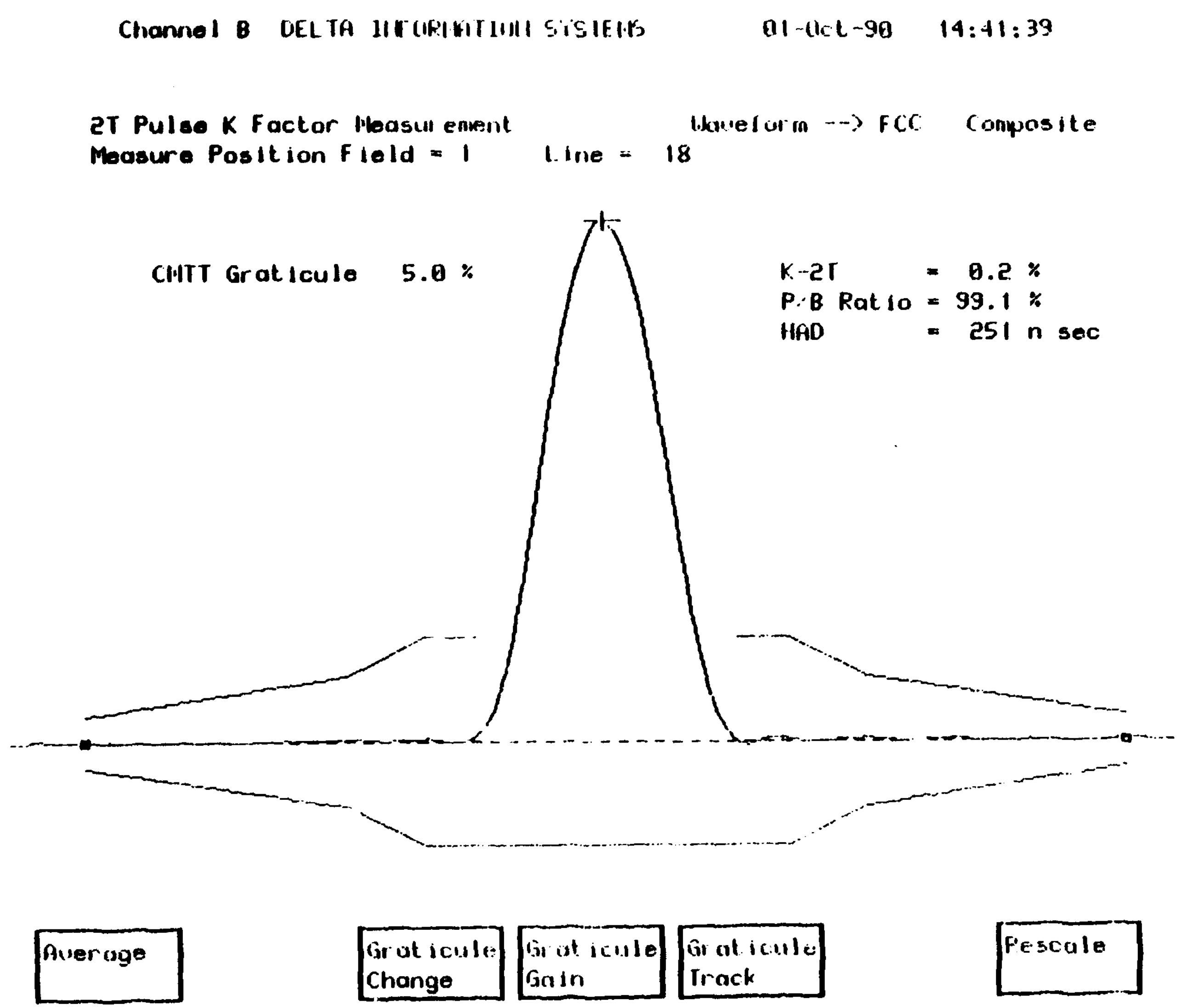


FIGURE 4

2T PULSE MEASUREMENT PRINTOUT

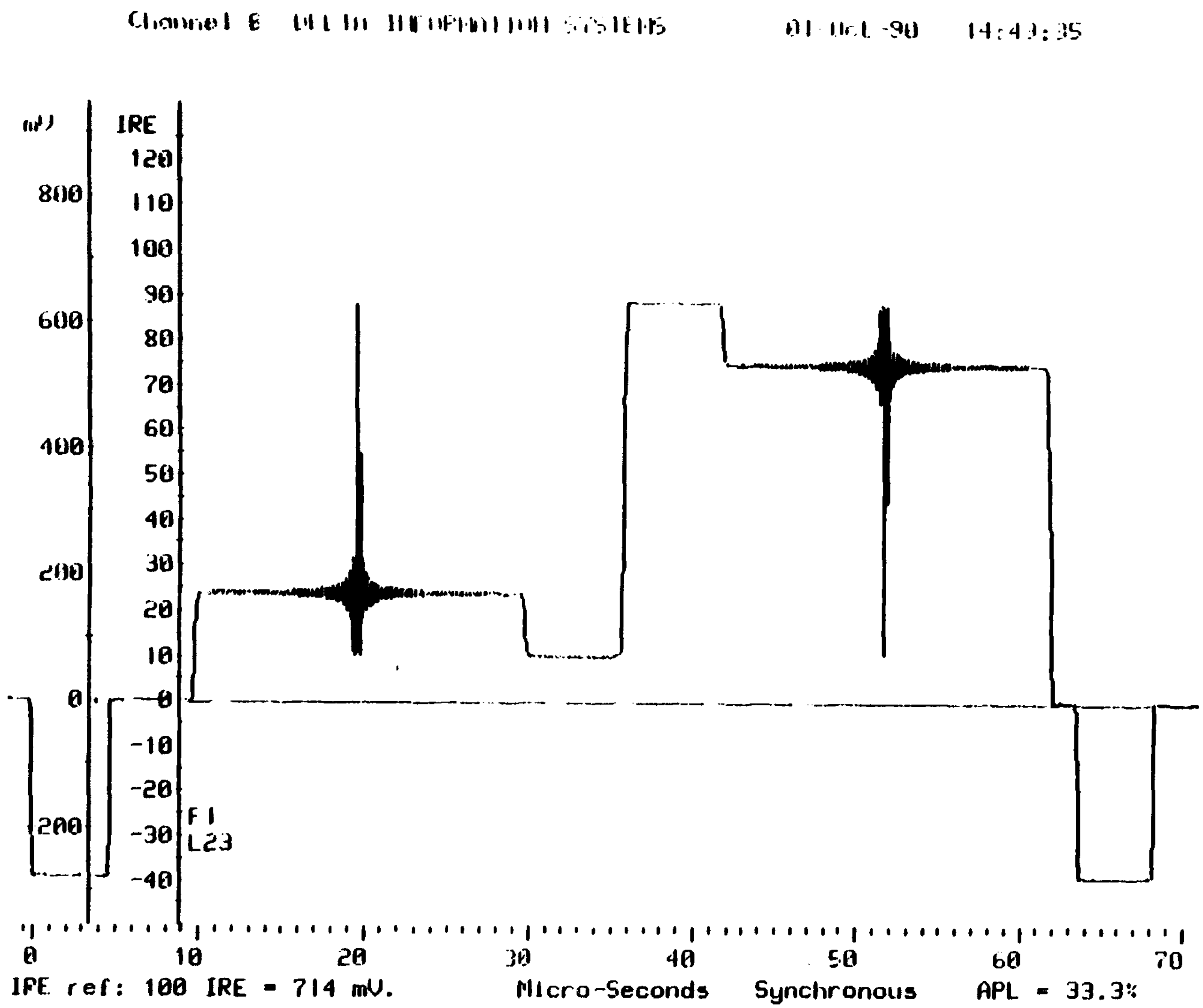


FIGURE 5

SIN X/X TEST WAVEFORM

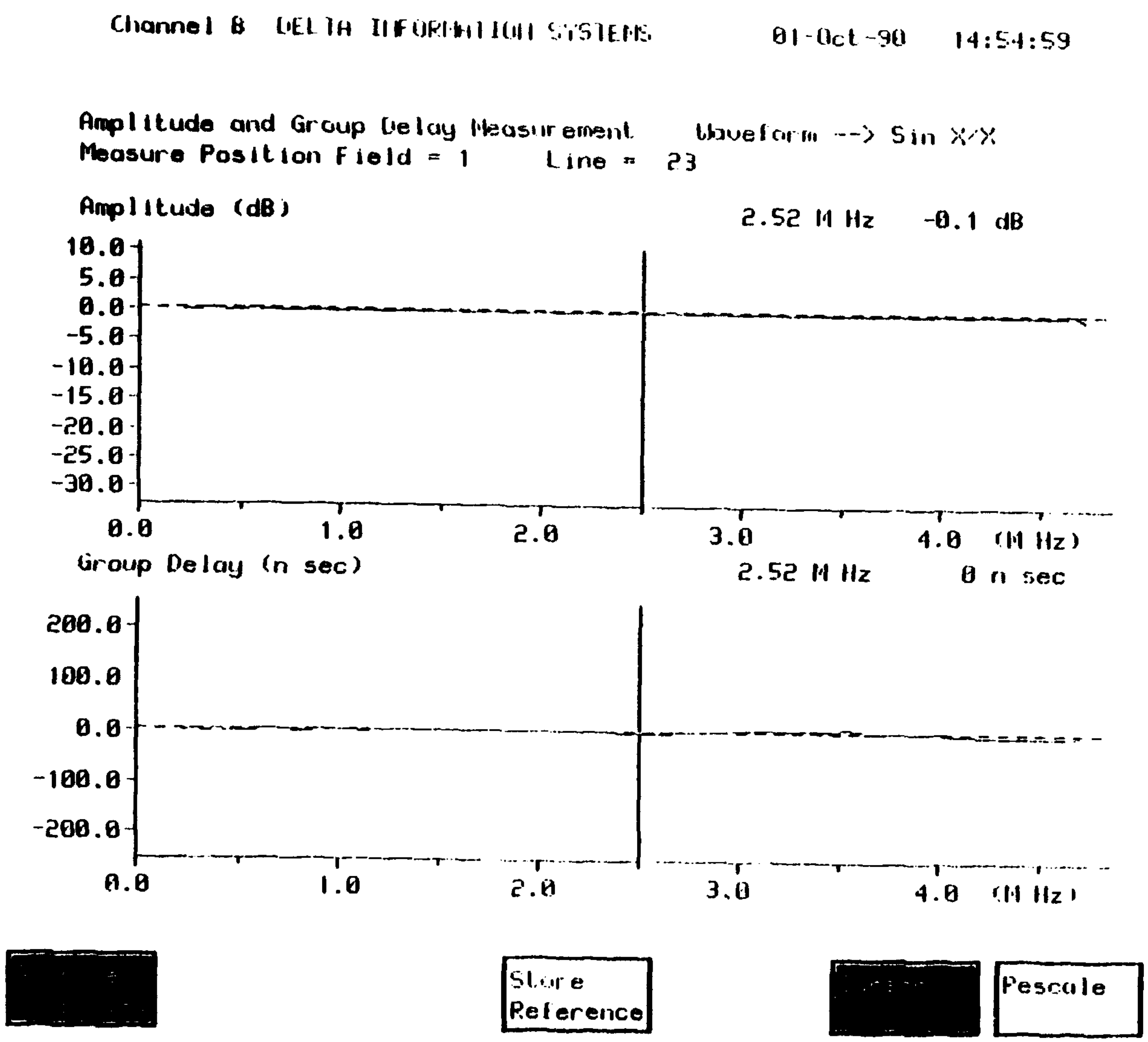


FIGURE 6

AMPLITUDE RESPONSE PRINTOUT

3. TEST RESULTS

Delta Information Systems has made numerous measurements on different codecs over the full range of bit rates from 64 to 1536 Kbps. It would be too cumbersome and largely redundant to report all results but a selection is shown on Table 1. Listing only one average value for each parameter per codec is fully justified by the fact (proven by measurements) that still picture parameters are not influenced by the digital portion of the codec and thus essentially independent from the operating bit rate. The reference values represent a combination of values taken from EIA Standards RS-170A and RS-250B, NTC-7, and CCIR Rec. 567-2. A few parameters not contained in these documents were taken from caution or alarm limits suggested for broadcast service by Tektronix in the VM-700 instructions.

The listed results show that most values fall within the long haul broadcast reference standards. The most significant exception is frequency response and other related parameters such as pulse/bar ratio and chrominance/luminance gain inequality which inherently cannot comply. Some frequency response measurements were made with a modified multiburst which replaces the insignificant frequencies above 3 MHz with values between 2 and 3 MHz which are very useful in describing codec performance. The response values clearly show the difference of the frequency responses of low and high bit rate range codecs. Correlation between multiburst and 2T pulse measurements is not as good as desirable. It shows that a single point measurement is neither

TEST SIGNAL			TEST PARAMETER	CODEC NO. AND BIT RATE RANGE 1 64/384 KBPS	2 64/384 KBPS	3 384/1536	REFER-ENCE VALUE
NTC - 7 Combination	Multi-burst Frequ. (MHz)	0.5	Frequency Response (dB)	-0.4	-0.3	-0.4	-0.4
		1.0		-2.0	-0.8	-1.0	-0.6
		2.0		-6.4	-4.6	-3.6	-0.8
		2.35		—	-13.8	-5.0	—
		2.7		—	-37	-8.4	—
		3.0		-24	-37	-18.5	-1.0
		3.58		-31	—	—	-0.6
		4.2		-34	—	—	-1.2
	Modulated Pedestal		Chrom Non-Lin Gain (%)	2.0	3.0	2.2	5
			Chrom Non-Lin Phase (Deg)	0.2	0.3	3.7	5
			Chrom/Lum Intermod (%)	0.2	0.3	0.7	4
FCC/NTC - 7 Composite	Modulated Step		Diff Gain (%)	1.3	3.5	3.1	10
			Diff Phase (Deg)	1.0	1.0	2.2	5
			Lum Non-Lin (%)	2.9	3.0	4.0	10

MEASUREMENT RESULTS AND REFERENCE VALUES
TABLE 1, SHEET 1

FCC/NTC - 7 Composite	Mod Pulse & Bar	Chrom/Lum Gain Inequ (%)	77	87	95	93
	Mod Pulse	Chrom/Lum Delay Inequ (nsec)	21	+6	-8	±60
	2T Pulse & Bar	Pulse-Bar Ratio (%)	78	73	77	94
	2T Pulse	K Factor (%)	6	5.5	4.1	2.5
		Half Ampl. Duration (nsec)	288	324	305	—
Black Burst & Pedestal	100%	Field Time Distortion (%)	0	0	0	3
	100%	Line Time Distortion (%)	0	0	0	2
	100%	S/N Ratio (dB)	65	61	61	54
	30%	S/N Ratio (dB)	66	65	61	54
Any		V Blank Field 1 (Lines)	23	22	22	21
		V Blank Field 2 (Lines)	23	23	23	21
		Hor Blank (microsec)	12.4	12.8	12.0	11.5
		SCH Phase (Deg)	-62	-34	+32	±45

MEASUREMENT RESULTS AND REFERENCE VALUES
TABLE 1, SHEET 2

sufficient nor reliable and therefore cannot be recommended.

A remark is in order about chrominance-luminance gain equality. The standard test signal for it is a subcarrier modulated 12.5T pulse with a half amplitude duration of 1562.5 nsec. The frequency spectrum of this pulse is too high to pass through the narrow filters needed for any color component signal without loss. A more realistic result and comparison between codecs can be obtained by using a 20T pulse with a half amplitude duration of 2500 nsec. The listed measurements on codec No. 1 were made with the standard 12.5T pulse while a modified 20T pulse was used for the others. This accounts for the large difference between the measured values for codecs No. 1 and 2.

An intentional deviation from the reference standard exists in the blanking widths which exceed the permissible maximum. This measure "clips" the edges of the picture and thus reduces the amount of required transmitted information. The H.261 format establishes its own values of line numbers and samples per line so that this feature will not be present.

4. CONCLUSION

Without making a specific recommendation at this time, the results contained in this document may serve as a first guide towards the establishment of a performance standard. Most still picture parameters, except frequency response and signal-to-noise ratio, are not likely to significantly impact the performance rating of a teleconferencing codec but cannot be disregarded.

Even though no measurements on a H.261 codec have been performed so far, the results are expected to be very similar. It is obvious that the 2:1 ratio in sampling rates will require two quite different frequency response standards for units operating in the CIF and QCIF formats.

Following is a summary of conventional still picture video parameters, including all that are called out in the latest version of the Draft Standard in Paragraphs 5.1.1 and 5.1.2. Each parameter is assigned a category of importance depending on its expected impact on the quality of a received teleconferencing picture. The categories are defined as follows:

A: Very important - must be maintained within specified limits and measured frequently on an established schedule.

B: Moderately important - not likely to have a noticeable impact on picture quality unless far outside specified limits - should be measured occasionally.

C: Least important - very unlikely to show any variation or degradation - if at all specified need be measured only during equipment acceptance tests.

Parameter	Category
Amplitude Response vs. Frequency Characteristic	A
Chrominance-to-Luminance Gain Inequality	B
Chrominance-to-Luminance Delay Inequality	B
2T Pulse/Bar Ratio	B
2T Pulse Half Amplitude Duration	B
Short-Time Waveform Distortion (K-Factor)	B
Baseline Distortion	C

Line-Time Waveform Distortion	B
Superstreaking	C
Field-Time Waveform Distortion	C
Long-Time Waveform Distortion (Bounce)	C
Insertion Gain and Insertion Gain Variation	C
Lunminance Nonlinearity	A
Differential Gain (50% APL)	B
Differential Gain (10% & 90% APL)	C
Differential Phase (50% APL)	B
Differential Phase (10% & 90% APL)	C
Chrominance-to-Luminance Intermodulation	C
Chrominance Nonlinear Gain	B
Chrominance Nonlinear Phase	B
SCH Phase Error	B
Dynamic Gain of Picture Signal	C
Dynamic Gain of Synchronizing Signal	C
Transient Synchronizing Signal Nonlinearity	C
Signal-to-Weighted-Random-Noise Ratio (10KHz to 4.2KHz)	A
Signal-to-Low-Frequency-Noise Ratio (0 to 0 KHz)	C
Signal-to-Periodic-Noise Ratio	C
Chroma Noise	C
Availability of Video Service	A

The above category assignments are based on both judgement and presently available measurement results. Some modifications may be forthcoming before the relevant parameters and their standard values can be finalized.

APPENDIX J

COMMITTEE T1
CONTRIBUTION

DOCUMENT NUMBER:

****

STANDARDS PROJECT: ANALOG INTERFACE PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TELECONFERENCING/VIDEO TELEPHONY SERVICE

****

TITLE: ORGANIZATION OF SECTION 5.1 OF THE DRAFT STANDARD (Document No. T1Q1.5/90-107)

****

ISSUE ADDRESSED: DRAFT STANDARD

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SOURCE: DELTA INFORMATION SYSTEMS, INC.

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DATE: JANUARY 22, 1991

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DISTRIBUTION TO: T1Q1.5 SUBWORKING GROUP ON VIDEO TELECONFERENCING/VIDEO TELEPHONY

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KEYWORDS: STANDARD, VIDEO, TELECONFERENCING, TELEPHONY

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DISCLAIMER:

SUBJECT: Organization of Section 5.1 (Video Signal Performance Characteristics) of the Draft Standard (Document Number T1Q1.5/90-107)

Section 5.1 of the subject document is presently outlined as follows.

5.1.1 Video Signal Linear Distortion

5.1.2 Video Signal Nonlinear Distortion

5.1.3 Temporal Characteristics

5.1.4 Spatial Characteristics

5.1.5 Video Signal Impairments Associated with Quantizing

Document T1Q1.5/90-118 defines "spatial resolution" as "a measure of the ability to accurately reproduce still scenes." Based on this definition, it is concluded that Sections 5.1.1, 5.1.2, and 5.1.5 measure the "spatial resolution" of a VTC/VT transmission channel. Since there appears to be an overlap between Sections 5.1.1, 5.1.2, 5.1.5, and Section 5.1.4 which is entitled "Spatial Characteristics" it is proposed to delete Section 5.1.4.

It is also proposed to change the title of Section 5.1.3 from "Temporal Characteristics" to "Motion Video Distortion."

The final organization of Section 5.1 is proposed as follows:

5.1.1 Video Signal Linear Distortion

5.1.2 Video Signal Nonlinear Distortion

5.1.3 Video Signal Impairments Associated with Quantizing

5.1.4 Motion Video Distortion